Tagged Fish Dynamics Model (TFDM) of Pacific Herring (*Clupea pallasi)* in British Columbia

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TAGGED FISH DYNAMICS MODEL (TFDM) OF PACIFIC HERRING (*Clupea pallasi*) IN BRITISH COLUMBIA

by

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ABSTRACT

Zhao, Z., Schweigert, J.F., Fu, C., and Flostrand, L. 2006. Tagged fish dynamics model (TFDM) of Pacific herring (*Clupea pallasi)* in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2661: vi + 59 p.

An object-oriented computer program was developed to integrate an age-structured stock and tagged fish dynamics model (TFDM) for Pacific herring (*Clupea pallasi*) in British Columbia together with a user friendly interface. The graphical interface allows the user to select a range of settings for input parameters some of which may be modified during run time. TFDM also allows for variation in the dynamics of the five major migratory herring populations with options for different recruitment functions, natural mortalities, and different methods for determining migration among populations. The modelling of the dynamics of tagged fish is the core component of TFDM. Each tag release, the event total number of tagged fish released in a particular year and region, experiences tagging related immediate mortality followed by: natural mortality and longer term chronic tagging related instantaneous mortality, migration, and fishery exploitation during their subsequent life history. The program generates outputs of simulated pre-fishery spawning biomass and tag recoveries from each tag release unit, as well as forecasts of future tag recoveries from releases in both recent years and in the upcoming year. Graphical outputs permit rapid visual comparisons between observed and simulated tag recoveries, given various parameter settings in the model.

RESUME

Zhao, Z., Schweigert, J.F., Fu, C., and Flostrand, L. 2006. Tagged fish dynamics model (TFDM) of Pacific herring (*Clupea pallasi)* in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2661: vi + 59 p.

Un programme orienté objet et une interface utiiisateur conviviale ont été créés pour intégrer un modèle structuré en âge de la dynamique des poissons marqués (TFDM) pour le Hareng du Pacifique (*Clupea pallasi*) en Colombie-Britannique. L'interface graphique permet à l'utilisateur de choisir parmi toute une gamme de paramètres d'entrée dont certains sont modifiables durant l'exécution. Le TFDM permet également de faire varier la dynamique de cinq grandes populations de harengs en modulant les différentes fonctions liées au recrutement et à la mortalité naturelle des poissons, ainsi que de déterminer de différentes manières les migrations au sein des populations. La modélisation de la dynamique des poissons marqués est la fonction centrale du TFDM. Chaque lot de poissons marqués remis à l'eau dans une région et une année données subit des pertes immédiates dues à la présence de la marque avant que n'entrent en jeu les processus suivants : la mortalité naturelle, une mortalité à long terme due à la présence de la marque, les migrations et l'exploitation halieutique. Le programme calcule la biomasse disponible avant le début de la pêche, le taux de récupération des poissons marqués pour chaque lot de poissons et les taux de récupération à prévoir pour les lâchés effectués au cours des dernières années et les lâchés futurs. Des graphiques permettent d'effectuer des comparaisons visuelles rapides entre les taux de récupération observés et simulés en fonction des divers paramètres ajustables du modèle.

INTRODUCTION

Pacific herring (*Clupea pallasi*) in British Columbia have been tagged since 1936 in three major tagging programs using three varieties of tags (Daniel *et al.* 1999, Flostrand and Schweigert 2003). Stainless steel internal metal tags (belly tag) were used from 1936 through 1967, Floy external anchor tags (Floy tag) from 1979-92, and internal coded wire tags (CWT) from 1999 to present (2004). Tagging has been conducted throughout the coast of British Columbia, concentrated in five major fishery assessment and management regions that represent the five major migratory stocks (Figure 1): Queen Charlotte Island (Stock 1); Prince Rupert (Stock 2); Central Coast (Stock 3): Strait of Georgia (Stock 4); and West Coast Vancouver Island (Stock 5).

Several models had been developed to explain herring straying or dispersal rates (Ware *et al.* 2000), spatial structure (Ware and Schweigert 2001), stock assessment (Schweigert 2004, Fu *et al.* 2004), and tagging related parameter estimation (Zhao *et al.* in prep.). In this report, we describe a computer program that combines a generic population dynamics model with a model of tagged fish dynamics (TFDM) and a user friendly graphical interface (GUI).

Using parameter values from previous herring tagging studies and biological survey data, TFDM projects stock biomass and simulates the dynamics of tagged fish to help understand the effects of key factors such as recruitment, natural mortality, immediate and longer-term tag induced mortality, migration, and exploitation on herring population dynamics and tag recovery. The forecast of tag recovery rates by TFDM provides a basis for developing a tagging strategy in future field applications.

METHODS

Overview of the computer software

The computer program is object-oriented and designed to be as general as possible. Detailed instructions on implementation are provided in the user's manual (Appendix I). The program includes three basic processes: set up of input data, running the model dynamics, and output of results (Figure 2). Data input has two components: default data from input text files and run time keyboard and mouse entry using GUI to modify uncertain parameters and to choose alternative options. The text file "dataFile.txt" (Appendix II) contains initial values for the number of simulation replicates, start year, end year, number of stocks, recruitment age, maximum age, number of fishing gears and other parameters whose sources are specified in Table 1. A subset of the simulation period can be chosen from the GUI during run time. The GUI also allows the user to reset the number of simulation replications, natural mortality rates, stock-recruitment options, tag induced instantaneous mortality rates for the three tag types, migration option, tag detection rates, and parameters for prediction of tag recovery rates. Another input text file "ObsRec.txt" contains the observed historical tag recoveries (Appendix III).

TFDM models two core functional components, one for the herring population dynamics and the other for the tagged fish sub-population. The population dynamics component simulates the processes of recruitment, migration, natural mortality, and exploitation. The tagged fish component simulates the processes of tag release, immediate tag induced mortality, migration, natural and long-term tag induced instantaneous mortalities, and subsequent recoveries from each tag release event. A forecast option of tag recoveries from tag releases in recent and in the coming year(s) is also included in TFDM. A Gaussian distrib ion function assuming a mean of zero and standard deviation of 1, (i.e. N (0, 1)), is used to generate random errors when required. The Gaussian function uses random seeds that are automatically generated and saved into a text file by the program. If the number of simulation replications increases, a larger number of random seeds will be automatically generated and written to the file.

The program outputs pre-fishery spawning biomass and tag recoveries in two ways: a text file report and graphical plots. The user can selectively output recoveries from a certain tag release event (released in a specific year and stock) into a text file. The program then tabulates simulated tag recoveries from each stock in each year after release together with the observed recoveries. Information on release stock by year and the number of tags released is also presented. Graphical plots display all simulation trajectories of spawning biomass along with their mean values, probability density distributions and cumulative probabilities of tag recoveries from each tag release event together with the number of tags released.

Model Structure

The model uses the following notation for clarity:

s = source stock,
d = destination stock,
y = year,
$stYr$ = start year,
$endYr$ = end year,
f = number of years at large for released fish,
a = age,
$recAge$ = recruitment age,
$maxAge$ = maximum age,
g = gear,
T = number of tags.

I. Population Dynamics Model Structure

TFDM assumes that stocks are in an equilibrium state prior to the simulation start year. Thus, initial abundance at the recruitment age and older can be calculated as:

$$\begin{cases} N^{o}_{s,a} = R^{o}_{s} & a = recAge \\ N^{o}_{s,a} = N^{o}_{s,a-1} \cdot e^{-M_{s,y,a-1}} & a > recAge \end{cases}$$

where R_s^o is stock specific virgin recruitment provided as input data and $M_{s,y,a-1}$ is the estimated instantaneous natural mortality rate for stock s, in year $y = stYr$ and at age a-1. The model includes an age specific natural mortality rate ($M_{s,a}$) based on an age independent stock specific natural mortality rate M_s where:

$$M_{s,a} = M_s - \alpha \cdot e^{A\beta} + \alpha \cdot e^{a\beta}$$

implying that if age $a = 4$, then $M_{s,a} = M_s$, and as age increases, $M_{s,a}$ increases with $\alpha = 0.13, \beta = 0.21$ (Tanasichuk 2000). Annual variation in natural mortality is incorporated using a lognormal distribution with the same coefficient of variation (cv^M) for each stock.

The initial spawning biomass for the years from *stYr-recAge* to *stYr* is:

$$B_s^o = \sum_a (N_{s,a}^o \cdot \delta_{s,y,a})$$

where $y = stYr$ and $\delta_{s,y,a}$ is the stock, year, and age specific fecundity, i.e. the product of weight and maturity rate ($\delta_{s,y,a} = W_{y,a}\chi_{s,y,a}$). The year and age specific body weight $W_{y,a}$ is provided in the input file "dataFile.txt". The stock, year, and age specific maturity rate $\chi_{s,y,a}$ is simulated by incorporating a lognormal error with coefficient of variation (cv^z) around the average maturity rate ($\overline{\chi}_{s,a}$) input from the file "dataFile.txt".

Age group dynamics are projected forward from the current year to the next year. Mature herring migrate to the spawning ground from February to April. Herring are currently harvested during the spawning season by the roe fishery. Prior to 1970 harvesting occurred in many areas during the fall inshore migration. After spawning, herring migrate offshore to the summer feeding grounds and in the fall again migrate inshore to the spawning grounds. To simulate these dynamics within a calendar year, the following sequence of events was modelled: herring at all ages experience natural mortality for one quarter of the year, age 2 herring recruit to the population, while mature herring migrate to and from the spawning grounds and are exploited by fisheries, then experience natural mortality for the remaining three quarters of the year.

Therefore, abundance and pre-fishery spawning biomass after experiencing natural mortality for one quarter of the year can be expressed as:

$$N_{s,y,a} = N_{s,a}^o \cdot e^{(-0.25M_{s,y,a})}, \text{if } y = stYr, a \geq recAge$$

$$N_{s,y,a} = N_{s,y-1,a-1} \cdot e^{(-0.25M_{s,y,a})}, \text{if } y > stYr, a > recAge$$

$$B_{s,y} = \sum_a (N_{s,y,a} \cdot \delta_{s,y,a})$$

The model assumes herring recruit to the population at the age of *recAge*. The new recruits in stock s and year y ($R_{s,y}$) join the modelled stock:

$$N_{s,y,a} = R_{s,y}$$

where a = *recAge*. There are two options for including recruitment values into the program: one is directly read from "dataFile.txt", and the other is to generate it using one of three recruitment functions:

1) Ricker stock-recruitment function adopted from Ianelli *et al.* (2001):

$$R_{s,y} = \frac{B_{s,y-recAge}}{\phi_s} e^{\alpha_s \cdot (1 - \frac{B_{s,y\text{-}recAge}}{\phi_s R_s^0})}$$

where $\phi_s = \frac{B_s^0}{R_s^0}$ is the expected spawning biomass of a single recruit, and

$\alpha_s = Log(-4h_s / (h_s - 1))$ with h_s being the steepness of the stock recruitment relationship.

2) Beverton-Holt stock-recruitment function adopted from Ianelli *et al.* (2001):

$$R_{s,y} = \frac{B_{s,y-recAge}}{\alpha_s + \beta_s \cdot B_{s,y-recAge}}$$

where $\alpha_s = B_s^o \cdot (1-h_s)/(4h_s \cdot R_s^o)$ and $\beta_s = (5h_s - 1)/(4h_s \cdot R_s^o)$.

3) Hockey-stick stock-recruitment function of Barrowman and Myers (2000) with minor modification:

$$R_{s,y} = \begin{cases} \alpha_s B_{s,y-recAge} & \text{if } B_{s,y-recAge} \le B_s^*(1-\nabla_s) \\ \alpha_s (B_{s,y-recAge} - \frac{(B_{s,y-recAge} - B_s^*(1-\nabla_s))^2}{4\nabla_s B_s^*}) & \text{if } B_s^*(1-\nabla_s) < B_{s,y-recAge} < B_s^*(1+\nabla_s) \\ \alpha_s B_s^* & \text{if } B_{s,y-recAge} \ge B_s^*(1+\nabla_s) \end{cases}$$

where $\alpha_s = 5h_s R_s^o / B_s^o$, $B_s^* = c_s B_s^o$ is the inflection point for spawning biomass, and $\nabla_s = 1/5h_s$ is the smoothness parameter, c_s is a coefficient for initial stock biomass and is provided in "dataFile.txt". Annual variation in recruitment is simulated using lognormal errors with a coefficient of variation of cv^R.

Abundance of mature herring from the age of recruitment is:

$$N^{z}_{s,y,a} = N_{s,y,a} \cdot \chi_{s,y,a},$$

and the age composition of mature herring is:

$$\Theta_{s,y,a} = N^{z}_{s,y,a} \Big/ \sum_{a} N^{z}_{s,y,a}$$

After accounting for the natural mortality rate in the first quarter of the year, the model simulates migration of herring among stocks in two ways. The first is to use migration rates among five stocks as estimated in Zhao *et al.* (in prep), and the second is to calculate migration rates based on the empirical straying functions from Ware and Schweigert (2001) with the following steps:

1) calculate total straying rate of stock *s* in year *y* using the density dependent empirical function of Ware and Schweigert (2001):

$$X_{s,y} = 0.33/(1+7.09e^{-0.0813B_{s,y}})$$

2) calculate dispersal rates from a source stock *s* to a destination stock *d* using the empirical distance dependent function of Ware and Schweigert (2001):

$$p_{s,d} = 0.75 \cdot e^{-0.603 \cdot D_{s,d}}$$

where $D_{s,d}$ is the distance between the source stock *s* and the destination stock *d*. Define $p_{s,d} = 0$ if $s = d$. The normalized dispersal rates are:

$$\overline{p}_{s,d} = p_{s,d} \Big/ \sum_{d} p_{s,d}$$

3) calculate the stray rates from a source stock *s* to a destination stock *d* in year *y*:

$$\omega_{s,d,y} = X_{s,y} \cdot \overline{p}_{s,d}$$

4) get the migration rates from a specific source stock *s* to each of the other four destination stock *d* in year *y*:

$$m_{s,d,y} = \begin{cases} \omega_{s,d,y} & if\ s \neq d \\ 1\text{-}X_{s,y} & if\ s = d \end{cases}$$

After migration (immigration and emigration), cumulative spawning biomass can be calculated as:

$$B^{n}_{s,y} = \sum_{d} (B_{d,y} \cdot \omega_{s,d,y}) - \sum_{s} (B_{s,y} \cdot \omega_{s,d,y})$$

where $\sum_{d}(B_{d,y}\cdot\omega_{s,d,y})$ is total immigration spawning biomass and $\sum_{s}(B_{s,y}\cdot\omega_{s,d,y})$ is total emigration spawning biomass. Cumulative stock abundance can be derived from cumulative spawning biomass:

$$N^{n}_{s,y,a}=B^{n}_{s,y}/(\overline{W}_{s,y,a}\cdot N^{z}_{s,y,a})$$

where $\overline{W}_{s,y,a}=W_{y,a}\cdot\chi_{s,y,a}/\sum_{a}\chi_{s,y,a}$. Stock abundance is updated after migration:

$$N^{m}_{s,y,a}=N_{s,y,a}+N^{n}_{s,y,a}$$

After migration, herring are subjected to exploitation ($\mu_{s,y,g}$). Catch at age can be calculated as:

$$C_{s,y,g,a}=\begin{cases}N^{m}_{s,y,a}\cdot\mu_{s,y,g}\cdot\varepsilon_{y,g,a} & \textit{if y is in the reduction fishery}\\ N^{m}_{s,y,a}\cdot\mu_{s,y,g}\cdot\varepsilon_{y,g,a}\cdot\chi_{s,y,a} & \textit{if y is in the roe fishery}\end{cases}$$

where $\varepsilon_{s,g,a}$ is the stock and age specific gear selectivity given in "dataFile.txt". Seine gear is assumed to be non-selective and selectivity for gillnets is estimated in Schweigert (2004). Stock abundance is updated again following exploitation:

$$N^{f}_{s,y,a}=\begin{cases}N^{m}_{s,y,a}\cdot(1-\sum_{g}\mu_{s,y,g}\cdot\varepsilon_{y,g,a}) & \textit{if y is in the reduction fishery}\\ N^{m}_{s,y,a}\cdot(1-\sum_{g}\mu_{s,y,g}\cdot\varepsilon_{y,g,a}\cdot\chi_{s,y,a}) & \textit{if y is in the roe fishery}\end{cases}$$

Finally, total abundance can be updated after experiencing natural mortality for another three quarters of the year:

$$N_{s,y,a}=N^{f}_{s,y,a}\cdot e^{(-0.75M_{s,y,a})}$$

II. Tagged Fish Dynamics Model Structure

Tagged fish dynamics are treated as a separate component of the total stock dynamics. Tagged fish migrate from a source stock and have the same properties as the rest of the fish in the destination stock. In addition, tagged fish also suffer immediate impacts from tagging and longer-term effects of the tag insertion. The model simulates the following processes for tagged fish: fish tagged in the previous year experience natural mortality and tag induced instantaneous mortality for a quarter of a year, tagged fish newly released recruit to the tagged fish component and experience immediate tagging related mortality, subsequently all tagged fish are subjected to migration, exploitation, and another three quarters of a year of natural and tagging related instantaneous mortalities.

Previously released fish may experience natural and tagging related instantaneous mortalities for the first quarter of a year:

$$T_{s,y,d,f+1,a+1} = T_{s,y,d,f,a} \cdot e^{-0.25(M_{s,y,a}+M_i^T)}$$

where tag type i is determined by tag release year y: if $y < 1979$, then $i = 1$; if $1979 <= y < 1999$, then $i = 2$; else $i = 3$.

The number of tags from a tag release event ($T_{s,y}^R$) can be distributed to each age group using the observed age composition data ($\theta_{s,y,a}$) from "dataFile.txt":

$$T_{s,y,a}^{\theta} = T_{s,y}^R \cdot \theta_{s,y,a}$$

A portion of the released herring experience an immediate tagging related mortality rate (ν_y) and die shortly after release:

$$T_{s,y,a}^I = T_{s,y,a}^{\theta} \cdot (1 - \nu_y)$$

Surviving tagged herring possibly stray to other stocks just as untagged herring, which is assumed to occur immediately prior to the spawning season,

$$T_{s,y,d,f,a}^m = T_{s,y,a}^I \cdot m_{s,d,y}$$

where $T_{s,y,d,f,a}^m$ is the age specific number of tagged fish released from stock s and year y and moving to stock d after f years at large (from 0 to the difference between *maxAge* and *recAge*). If the estimated migration rates ($m_{s,d}$) are used, then $m_{s,d,y}$ is replaced by $m_{s,d}$ in the above formula.

Just as for untagged herring, tagged herring experience the same exploitation rate ($\mu_{d,y,g}$) after migration, and they are recovered according to the following equations:

$$C_{s,y,d,f,g,a}^T = T_{s,y,d,f,a}^m \cdot \mu_{d,y,g} \cdot \varepsilon_{y,g,a} \cdot \pi_{d,y} \quad only\ if\ f = 0$$

$$C_{s,y,d,f,g,a}^T = T_{s,y,d,f,a}^m \cdot \mu_{d,y,g} \cdot \varepsilon_{y,g,a} \quad if\ f > 0$$

where $C_{s,y,d,f,g,a}^T$ is the age specific number of tagged fish released from stock s and year y, and recovered in stock d after f years at large by gear g. The parameter $\pi_{d,y}$ is introduced to account for in-season recoveries of tagged fish during the release year as a result of fishing occurring shortly after release of the tagged fish (Zhao *et al.*, in prep.). Historical recovery data suggests that many tagged fish were recovered during the release year indicating an overlap in fishery and tag release locations.

To estimate the observed tag recoveries in the simulation, total tag recoveries must be adjusted by the search ratio $\psi_{s,y,g}$, and detection rate λ_y based on the formula:

$$C^{T*}_{s,y,d,f,g,a} = C^{T}_{s,y,d,f,g,a} \cdot \psi_{s,y,g} \cdot \lambda_y$$

Stochastic tag recoveries in the simulation are generated by applying a lognormal error to the $C^{T*}_{s,y,d,f,g,a}$ with coefficient of variation cv^T.

An estimate of the tagged herring remaining in the total population after the fisheries by all gears can be calculated as:

$$T^{\mu}_{s,y,d,f,a} = T^{m}_{s,y,d,f,a} - \sum_{g} C^{T}_{s,y,d,f,g,a}$$

Finally, the tagged fish can move through the population after experiencing natural and tagging related instantaneous mortalities for the remaining three quarters of a year:

$$T_{s,y,d,f,a} = T^{\mu}_{s,y,d,f,a} \cdot e^{-0.75(M_{s,y,a}+M^{T}_{i})}$$

III. Prediction of tag recoveries

It is of practical interest to predict expected tag recoveries in the most recent years and in the coming year. TFDM generates the predicted recoveries by using expanded data arrays and assuming parameter values for the future years. For the tag induced immediate mortality rate, the ratio of catch searched for tags, tag detection rate, and fishery exploitation rates, there are two options to set their values. One is to include the user specified values from the GUI, and the other is to use the default values generated from TFDM. All other parameters are automatically calculated by TFDM. TFDM generates as their average values , the tag induced immediate mortality rate, the tag detection rate, and the coefficient for tagging and fishery overlap for the coming year ($\nu_{endYr+1}$, $\lambda_{endYr+1}$, and $\pi_{d,endYr+1}$) in the CWT program period. TFDM sets migration rates, and tagged fish age composition for the coming year ($m_{s,d,endYr+1}$, and $\theta_{s,endYr+1,a}$) at the same values as those in year *endYr*. It also sets default exploitation rates at 0.1 for both seine and gillnet ($\mu_{d,endYr+1,g} = 0.1$) and the default ratio of catch searched for tags at 0.33 ($\psi_{d,endYr+1,g} = 0.33$). Since natural mortality rate and long-term tagging related instantaneous mortality rate are not year specific in TFDM, they remain unchanged. To conduct projections for more years, the same parameter values used in year *endYr*+1 can be assumed.

APPLICATION RESULTS

Pre-fishery spawning biomass

The computer program presents simulated pre-fishery spawning biomass both in a saved results file and in graphical plots. Table 2 lists the simulated pre-fishery spawning biomass averaged over 500 replications using recruitment values and straying rates entered in the file "dataFile.txt". Figure 3 displays the graphical plots of 500 trajectories of simulated pre-fishery spawning biomass taken directly from TFDM graphical output. The patterns are similar to those of Schweigert (2004) and Fu *et al.* (2004). Figure 4 shows the graphical plots of simulated pre-fishery spawning biomass using recruitment values generated by three different stock-recruitment functions. The simulated average pre-fishery spawning biomass illustrates roughly similar patterns for the three recruitment functions: pre-fishery spawning biomass reached its lowest point for almost all stocks around 1966, but in less than five years they rebounded and achieved higher levels than those of earlier years. Compared with those in Figure 3, the trajectories in Figure 4 tend to vary more widely.

Tag recoveries

The program provides information on simulated tag recoveries in a saved results file and in graphical plots. To demonstrate the software, tag recoveries were obtained using simulated straying rates given in "dataFile.txt" and default values for the other parameters. Appendix IV lists the simulated tag recoveries from one of the 500 replications tabulated together with the observed values from each tag release unit, showing the release year, region (stock) and the number of tags released. The differences between observed and simulated tag recoveries are smaller for Floy tags and CWT. Figure 5-1 displays the probability density distributions and cumulative probabilities for tag recoveries from a tag release event in stock 2 in 2001. Each panel can be magnified by a mouse double click as shown in Figure 5-2. For best viewing, the software can change the x-axis scaling as shown in the last two panels of Figure 5-2. A description of the components of the figures is presented in Figure 6.

DISCUSSION

The computer software described here is a general population dynamics and tagged fish simulation tool that is able to provide many more features than those demonstrated above. However, in the discussion the focus will be on issues relating to straying rates, stock-recruitment functions, and the prediction of tag recoveries.

Straying rates among herring stocks are an important factor in determining appropriate harvesting rates and management objectives. Which of the two options chosen to set stray rates for the simulation will affect both the simulated pre-fishery spawning biomass and the simulated tag recoveries. The stray rates given in the input file "dataFile.txt" are taken from Zhao *et al.* (in prep.), which were estimated using tag recoveries from 1951 to 2003 in the five major stocks. Program-generated straying rates are calculated based on the distance matrix and the empirical straying function of Ware and

Schweigert (2001) who based their calculation on nine data points (one in 1982, three in 1989, four in 1990, and one in 1991) in 4 qualified years. We noticed that the stray rates appear unusually high during the period from 1989 to 1991, and as a result, the empirical straying function may result in higher estimated straying rates and may not be representative of long-term average rates. By comparing the simulated with observed tag recoveries, the user may be able to choose a better straying rate option, which is beyond the scope of this report but is discussed more fully by Zhao *et al.* (in prep.). TFDM provides three different functions for producing stock-recruitment values. By comparing the pre-fishery spawning biomass, simulated using different stock-recruitment functions with those generated using default recruitment values, the user can select the most appropriate stock-recruitment function and suitable values for parameters such as the steepness at the origin.Prediction of tag recoveries can be used for designing the number and distribution of tag releases for a tagging program in the coming years. Other factors that can be controlled to some extent are also included in the GUI for the user to specify in order to investigate the range of expected number of recovered tags. These factors include the exploitation rates for different fishing gears, the proportion of catch searched for tags, the tag detection rate, and the tagging quality, as evidenced by the immediate tagging related mortality rate TFDM software users should be able to develop a tagging study that provides a reasonable expectation of sufficient tag recoveries to address the objectives of the study with statistical rigour.

ACKNOWLEDGEMENTS

The project was funded by the Herring Conservation and Research Society. We appreciate the discussions with Dr. D. Hay and Bruce McCarter regarding the belly and Floy tagging programs. We appreciate the efforts of those who collected, verified, and tabulated the many tag releases and returns and developed and maintained the tagging databases.

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Ware, D.M., and Schweigert, J.F. 2001. Metapopulation structure and dynamics of British Columbia herring. Can. Sci. Advis. Secretariat. Res. Doc. 2001/127.

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Table 1. Model variables, parameters and data sources

Data	Source
$D_{s,d}$, distance between source stock *s* and destination stock *d*	Ware and Schweigert 2001
R_s^o, initial recruitment of stock *s*	Fu *et al.* 2004
M_i^T, tag induced instantaneous mortality rates of tag type *i*	Zhao *et al.* In prep
ν_y, tag induced instant mortality rates in year *y*	Zhao *et al.* In prep.
$W_{y,a}$, fish weight in year *y* at age *a*	Schweigert 2004
$\pi_{d,y}$, overlapping coefficient of stock *d* in year *y*	Zhao *et al.* In prep.
$R_{s,y}$, annual recruitment of stock *s* in year *y*	Fu *et al.* 2004
$m_{s,d}$, migration rate from stock *s* to stock *d*	Zhao *et al.* In prep.
$\varepsilon_{s,g,a}$, gear selectivity of stock *s*, gear *g* at age *a*	Schweigert 2004
M_s, instantaneous natural mortality rate in stock *s*	Fu *et al.* 2004
α and β, age specific natural mortality coefficients	Tanasichuk 2000
$\mu_{s,y,g}$, exploitation rate in stock *s*, in year *y*, and of gear *g*	Fu *et al.* 2004
$\psi_{s,y,g}$, ratio of catch searched for tag in stock *s*, in year *y* of gear *g*	Flostrand and Schweigert 2003
λ_y, tag detection rate of searched fish in year *y*	Flostrand and Schweigert 2003

Table 2. Average pre-fishery spawning biomass of stocks 1 to 5, simulated using default recruitment values from 1951 to 2003.

Year	*Stock 1*	*Stock 2*	*Stock 3*	*Stock 4*	*Stock 5*
1951	13.74	27.25	26.41	74.83	39.75
1952	8.07	20.45	10.76	24.04	22.01
1953	3.71	5.48	2.56	35.14	2.12
1954	8.93	18.40	29.05	60.31	14.76
1955	15.76	6.74	22.62	23.09	7.49
1956	34.31	14.95	28.59	31.51	49.85
1957	5.15	20.22	9.04	21.77	75.64
1958	0.78	8.44	3.94	8.98	67.39
1959	7.68	26.67	19.26	29.67	65.06
1960	3.82	23.02	6.90	30.63	12.38
1961	10.83	44.38	20.09	23.73	3.97
1962	23.23	33.55	17.82	39.35	12.19
1963	29.02	26.67	20.47	29.34	12.86
1964	17.65	35.87	3.61	31.15	12.75
1965	5.94	24.26	4.15	14.26	8.22
1966	0.81	5.45	4.63	15.23	5.71
1967	0.87	2.73	3.55	8.34	5.23
1968	1.72	5.79	4.47	15.36	6.08
1969	3.17	8.91	7.06	27.64	13.94
1970	6.15	16.10	13.92	48.28	28.36
1971	13.07	20.98	22.15	71.06	51.48
1972	27.28	20.00	27.43	92.89	72.48
1973	37.36	18.16	23.76	77.92	70.16
1974	32.38	23.43	23.32	64.95	53.40
1975	32.09	23.22	28.37	75.78	67.71
1976	29.45	24.43	31.43	90.94	66.99
1977	24.48	24.02	25.08	117.67	50.67
1978	18.10	16.28	18.83	117.22	59.61
1979	13.07	11.49	13.36	101.44	51.81
1980	35.84	19.19	27.70	85.04	49.71
1981	32.13	22.75	32.34	97.15	63.30
1982	21.05	23.30	31.83	101.59	51.49
1983	14.57	26.04	24.58	98.45	40.01
1984	15.50	41.53	16.79	79.97	28.73
1985	16.43	42.37	17.90	75.20	35.95
1986	13.69	38.08	17.56	85.32	55.03
1987	11.16	39.34	18.62	79.32	47.01
1988	21.10	38.58	38.27	79.73	44.84
1989	21.59	34.61	34.19	72.26	39.80
1990	16.22	27.33	23.21	78.64	35.61
1991	11.31	29.96	21.36	71.53	27.58
1992	19.12	39.95	44.46	91.60	36.67
1993	13.32	35.86	37.20	100.09	39.13
1994	7.64	26.22	28.36	103.54	33.45
1995	8.30	26.11	19.65	98.40	28.51
1996	10.52	30.93	16.53	85.59	26.12
1997	12.73	30.06	29.90	93.67	49.42
1998	18.60	32.29	33.79	87.50	40.74
1999	15.31	30.68	28.31	93.42	37.74
2000	10.95	28.51	23.86	91.66	28.27
2001	9.24	27.44	17.19	98.01	24.66
2002	8.69	23.53	16.53	105.34	26.83
2003	10.81	34.06	25.85	140.71	35.17

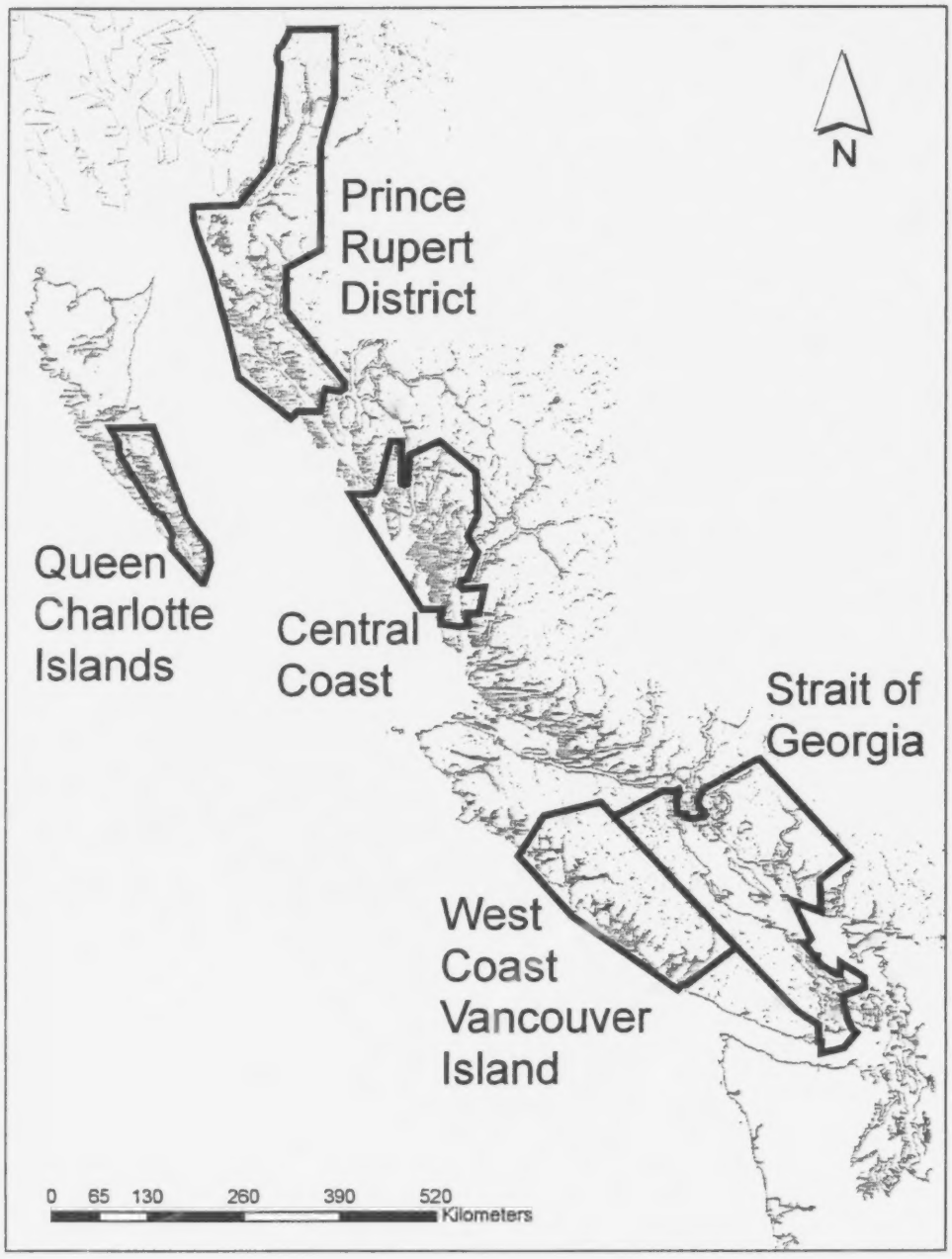

Figure 1. The five major herring stock assessment and fishery management regions in British Columbia used for tagging programs

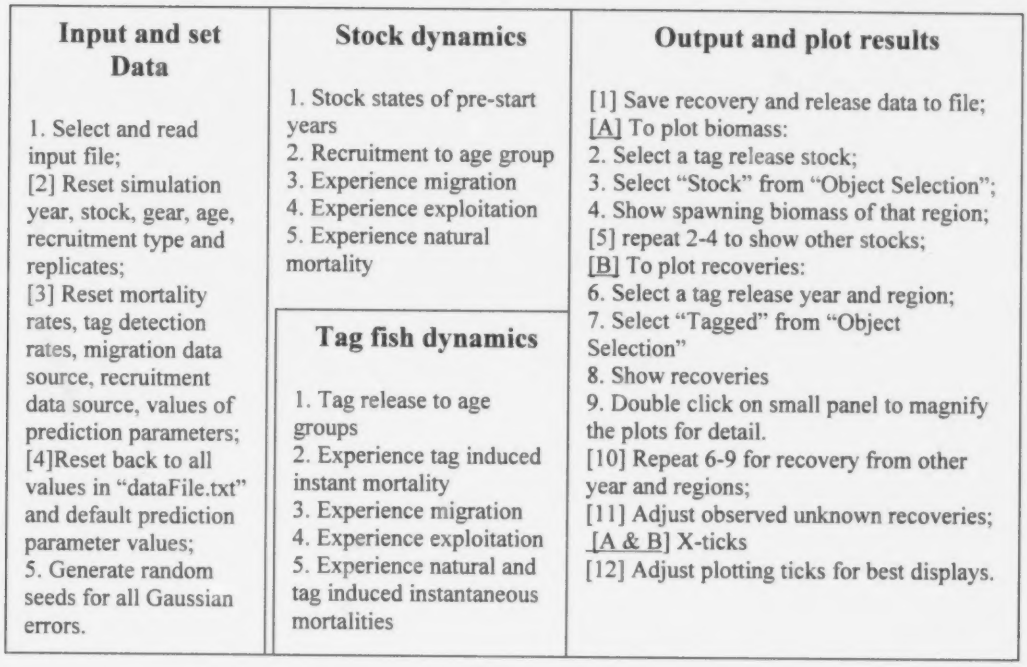
Input and set Data
1. Select and read input file;
[2] Reset simulation year, stock, gear, age, recruitment type and replicates;
[3] Reset mortality rates, tag detection rates, migration data source, recruitment data source, values of prediction parameters;
[4]Reset back to all values in "dataFile.txt" and default prediction parameter values;
5. Generate random seeds for all Gaussian errors.
Stock dynamics
1. Stock states of pre-start years
2. Recruitment to age group
3. Experience migration
4. Experience exploitation
5. Experience natural mortality
Tag fish dynamics
1. Tag release to age groups
2. Experience tag induced instant mortality
3. Experience migration
4. Experience exploitation
5. Experience natural and tag induced instantaneous mortalities
Output and plot results
[1] Save recovery and release data to file;
[A] To plot biomass:
2. Select a tag release stock;
3. Select "Stock" from "Object Selection";
4. Show spawning biomass of that region;
[5] repeat 2-4 to show other stocks;
[B] To plot recoveries:
6. Select a tag release year and region;
7. Select "Tagged" from "Object Selection"
8. Show recoveries
9. Double click on small panel to magnify the plots for detail.
[10] Repeat 6-9 for recovery from other year and regions;
[11] Adjust observed unknown recoveries;
[A & B] X-ticks
[12] Adjust plotting ticks for best displays.

Figure 2. TFDM general model structure. Number or letter in "[ ]" indicates an optional process.

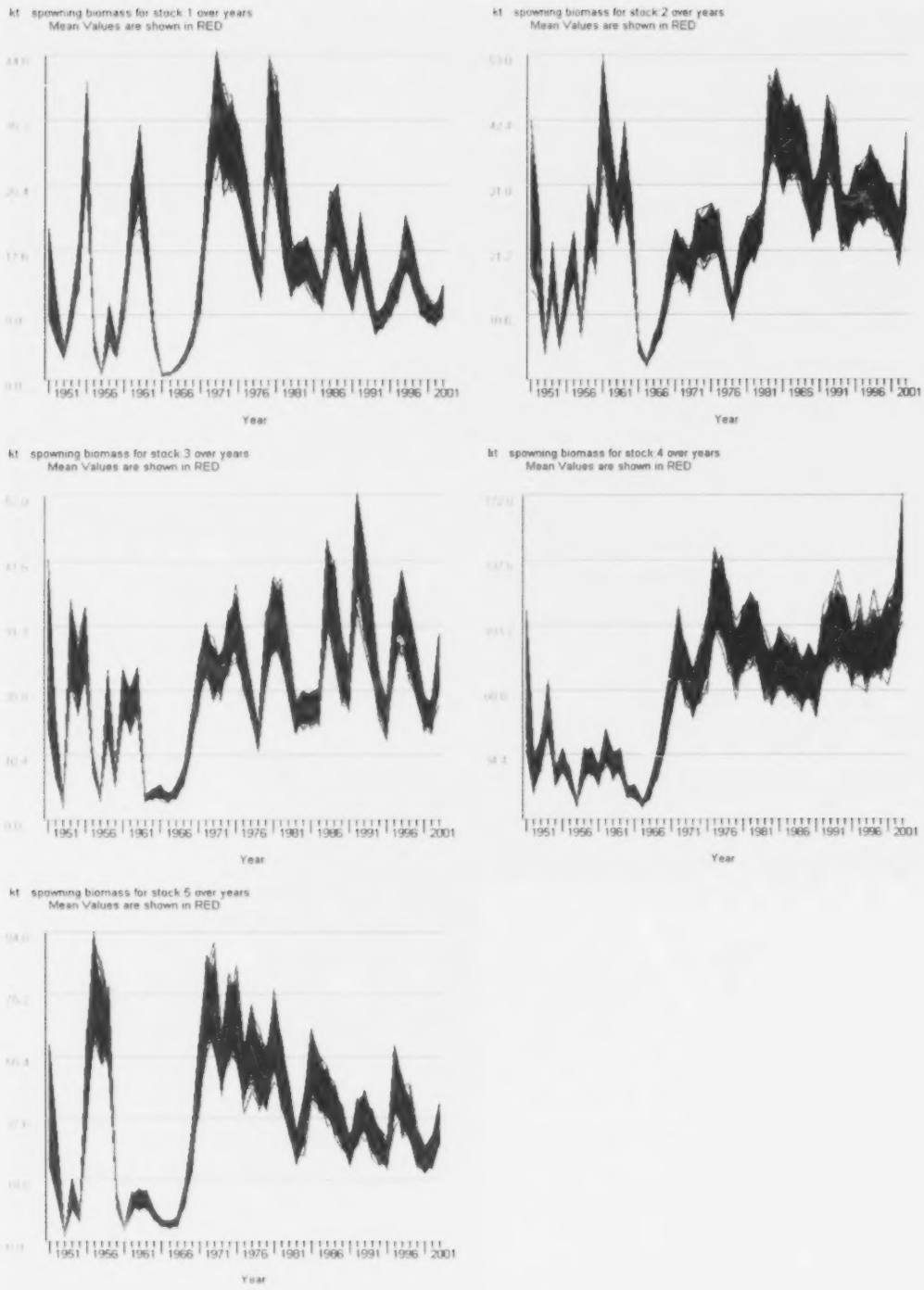
kt spawning biomass for stock 1 over years
Mean Values are shown in RED
kt spawning biomass for stock 2 over years
Mean Values are shown in RED
kt spawning biomass for stock 3 over years
Mean Values are shown in RED
kt spawning biomass for stock 4 over years
Mean Values are shown in RED
kt spawning biomass for stock 5 over years
Mean Values are shown in RED
1951 1956 1961 1966 1971 1976 1981 1986 1991 1996 2001
Year

Figure 3. Simulated pre-fishery spawning biomass from 1951 to 2003 using default recruitment values for stocks 1 to 5 (taken from TFDM output of 500 replicates).

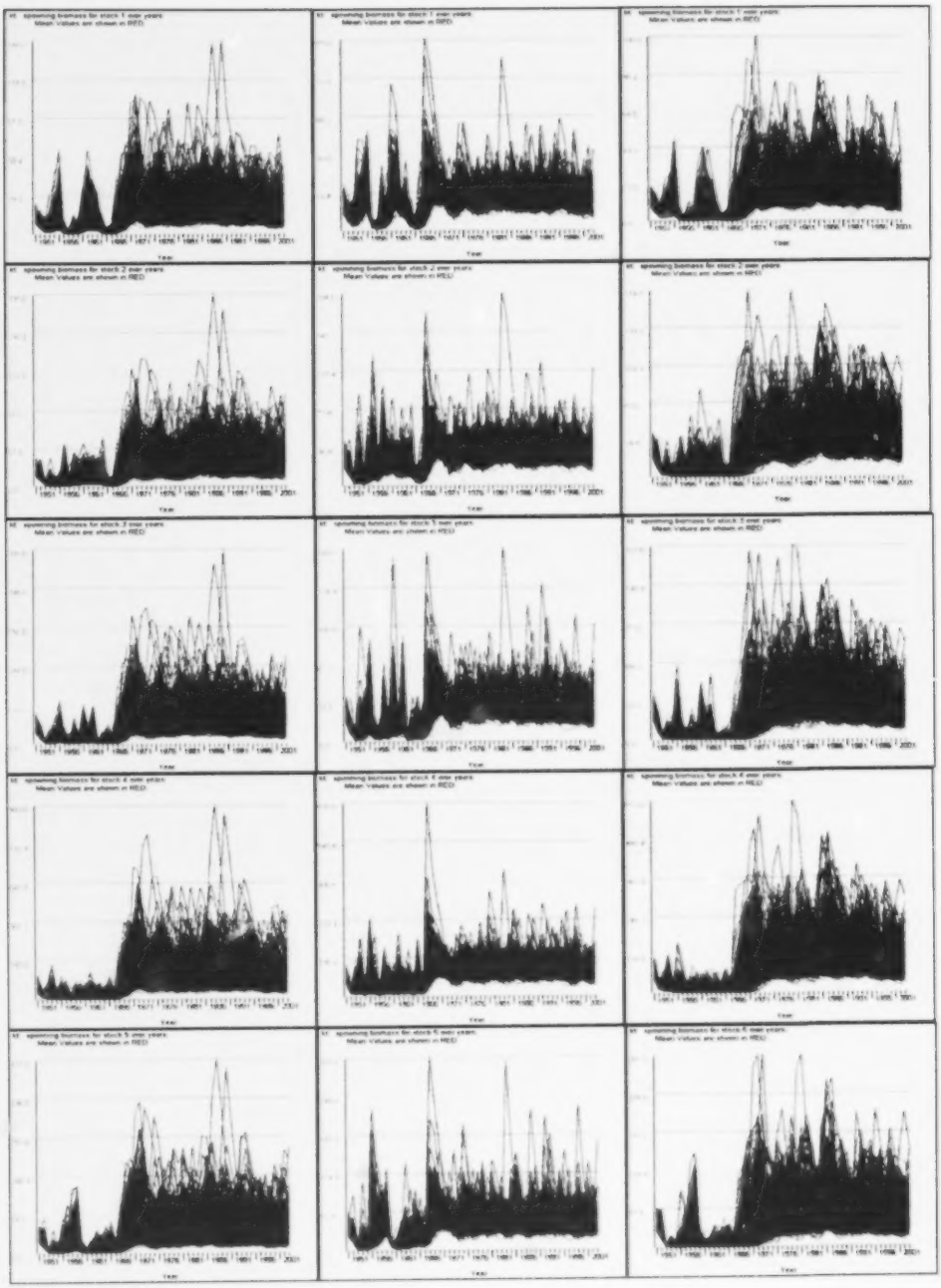

Figure 4. Results using different recruitment functions: first column using Beverton-Holt model, second column using Ricker model, and the third column using Hockey Stick function. The blue lines display all trajectories and red line displays the average values (output from the TFDM program resulting from 500 replicates).

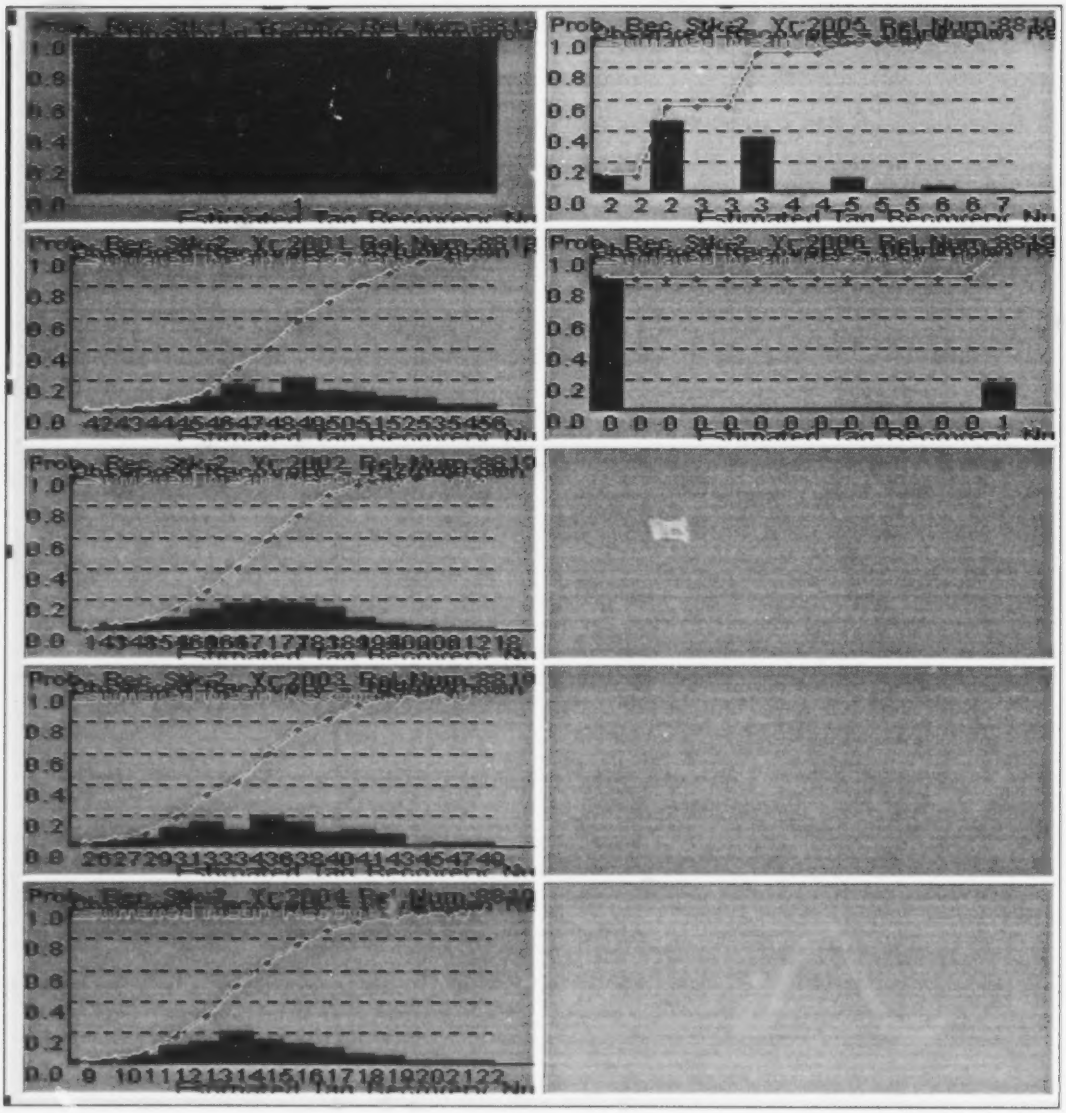

Figure 5-1. A summary of recoveries simulated from the tag release event for stock 2 in 2001 in small panes. The top to bottom left-to-right sequence of panels displays the nonzero recoveries for the five stocks (ordered from 1 to 5) over a period of 8 years of tags at large.

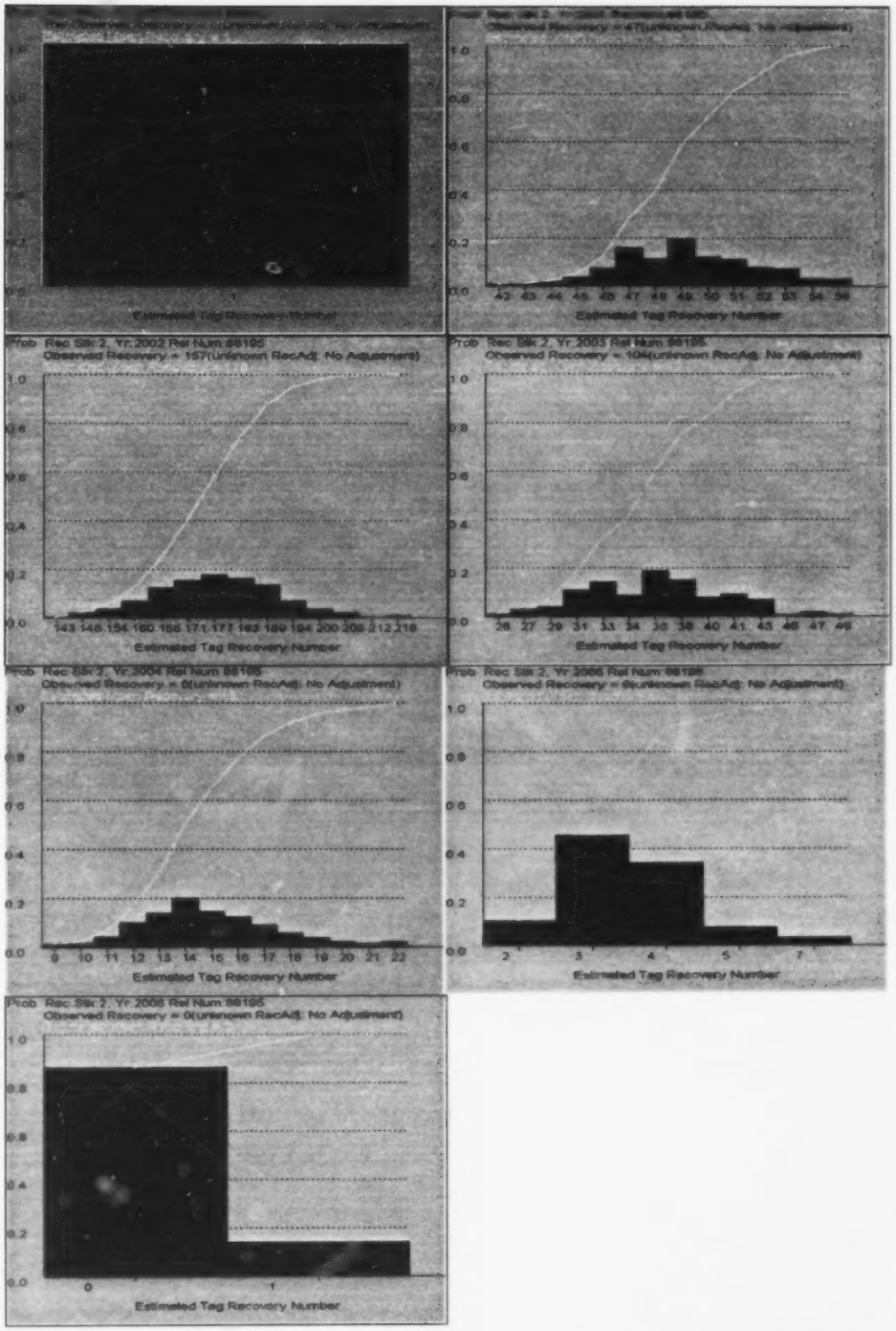
Estimated Tag Recovery Number
Prob Rec Stk 2, Yr 2002 Rel Num 68195
Observed Recovery = 157(Unknown RecAdj; No Adjustment)
Prob Rec Stk 2, Yr 2003 Rel Num 68195
Observed Recovery = 104(Unknown RecAdj; No Adjustment)
Prob Rec Stk 2, Yr 2004 Rel Num 68195
Observed Recovery = 0(Unknown RecAdj; No Adjustment)
Prob Rec Stk 2, Yr 2005 Rel Num 68195
Observed Recovery = 0(Unknown RecAdj; No Adjustment)
Prob Rec Stk 2, Yr 2006 Rel Num 68195
Observed Recovery = 0(Unknown RecAdj; No Adjustment)

Figure 5-2. Expanded versions of the plots of all panels in Figure 5-1.

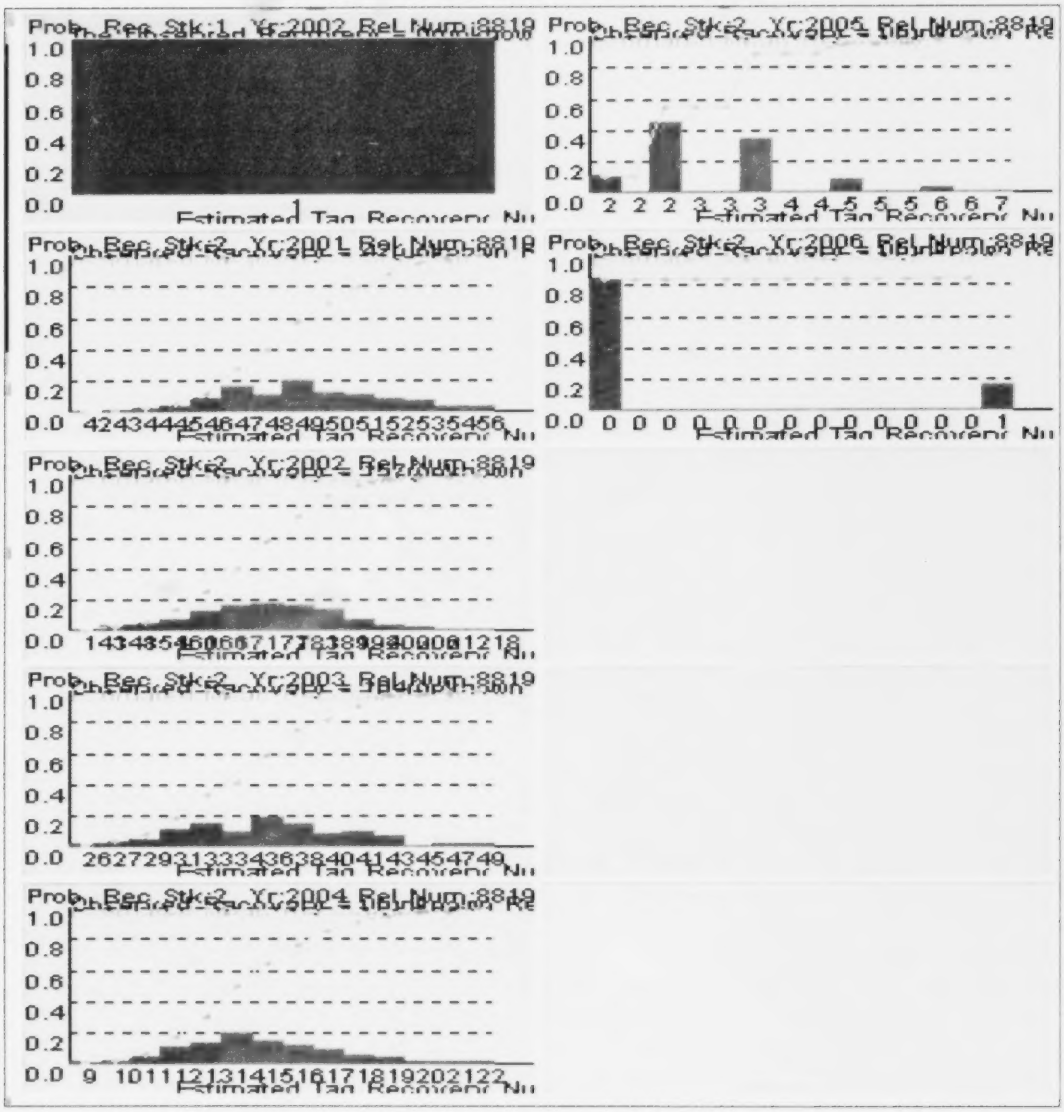

Figure 5-1. A summary of recoveries simulated from the tag release event for stock 2 in 2001 in small panes. The top to bottom left-to-right sequence of panels displays the nonzero recoveries for the five stocks (ordered from 1 to 5) over a period of 8 years of tags at large.

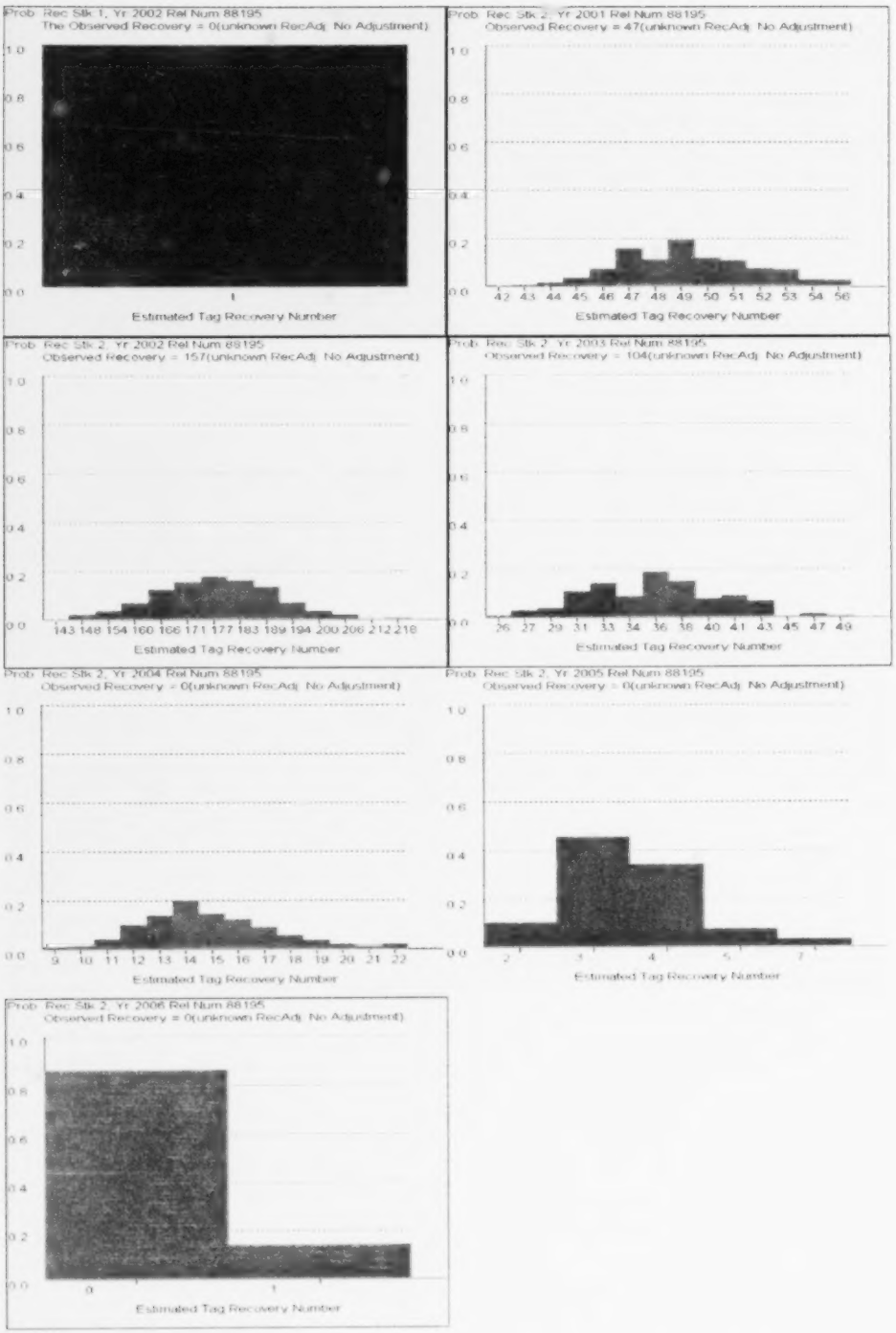
Prob. Rec Stk 1, Yr 2002 Rel Num 88195
The Observed Recovery = 0(unknown RecAdj. No Adjustment)
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2001 Rel Num 88195
Observed Recovery = 47(unknown RecAdj. No Adjustment)
42 43 44 45 46 47 48 49 50 51 52 53 54 56
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2002 Rel Num 88195
Observed Recovery = 157(unknown RecAdj. No Adjustment)
143 148 154 160 166 171 177 183 189 194 200 206 212 218
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2003 Rel Num 88195
Observed Recovery = 104(unknown RecAdj. No Adjustment)
26 27 29 31 33 34 36 38 40 41 43 45 47 49
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2004 Rel Num 88195
Observed Recovery = 0(unknown RecAdj. No Adjustment)
9 10 11 12 13 14 15 16 17 18 19 20 21 22
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2005 Rel Num 88195
Observed Recovery = 0(unknown RecAdj. No Adjustment)
Estimated Tag Recovery Number
Prob. Rec Stk 2, Yr 2006 Rel Num 88195
Observed Recovery = 0(unknown RecAdj. No Adjustment)
Estimated Tag Recovery Number

Figure 5-2. Expanded versions of the plots of all panels in Figure 5-1.

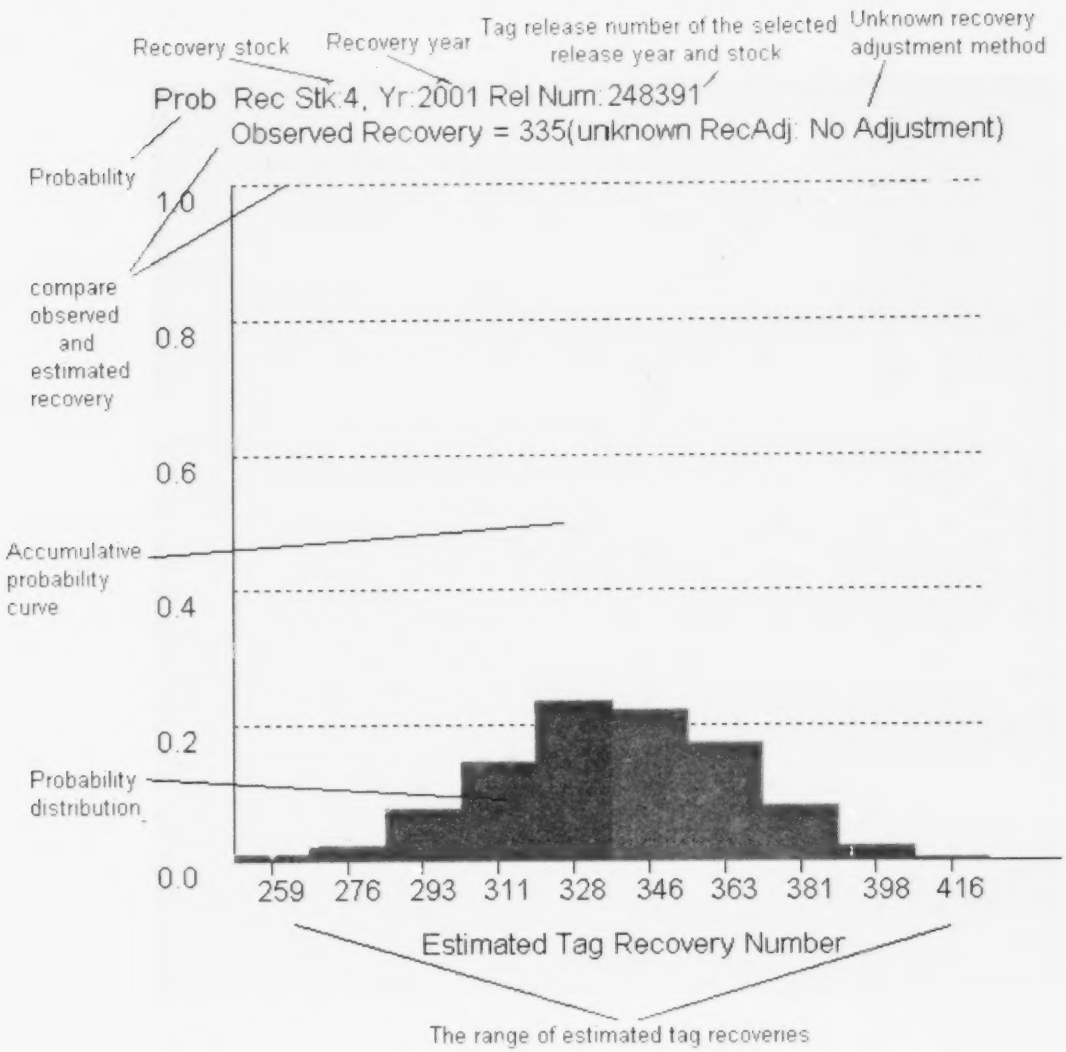

Figure 6. Description of the components of the graphical output from the TFDM modelling software.

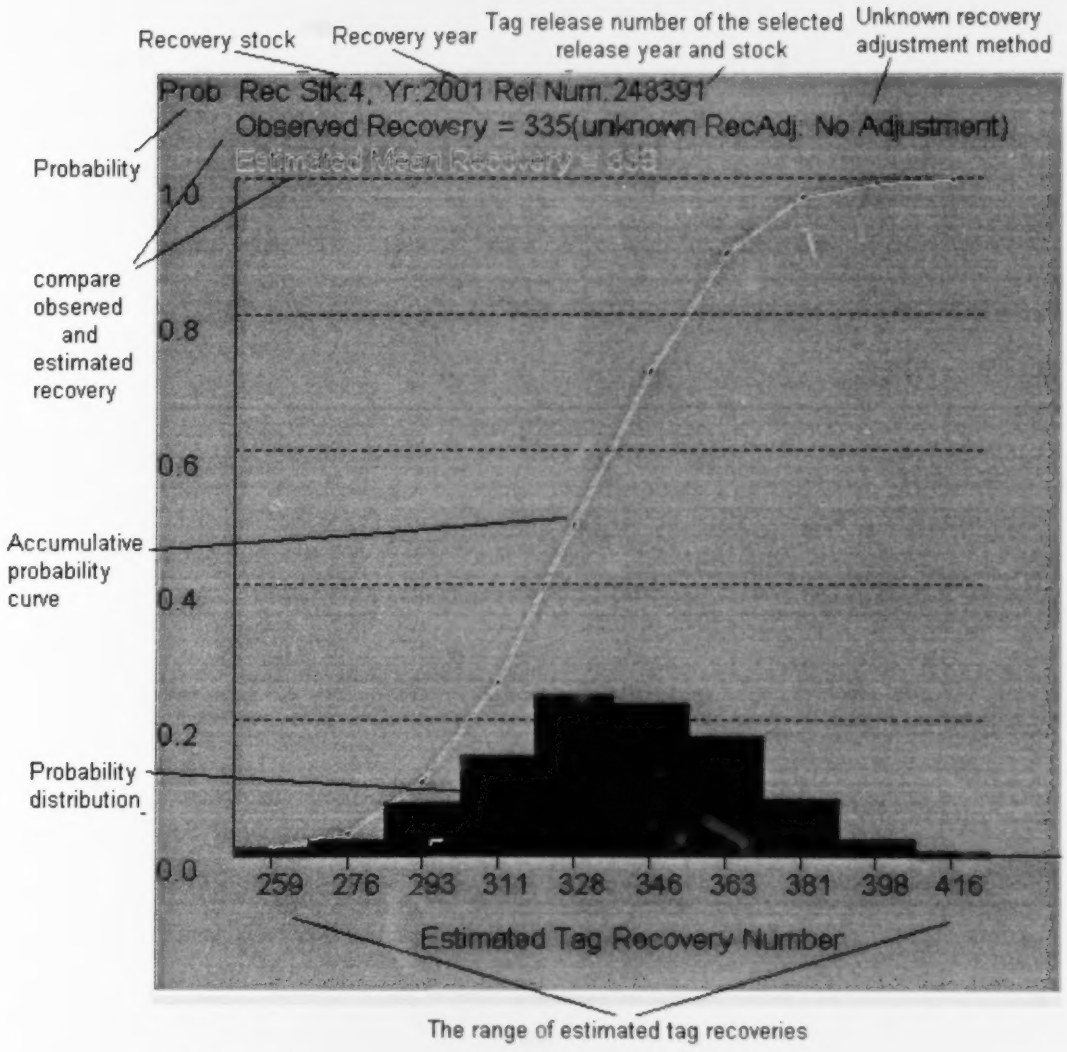

Figure 6. Description of the components of the graphical output from the TFDM modelling software.

Appendix I

User's Manual

Pacific Herring Stock and Tagged Fish Dynamics Model (TFDM)

Department Fisheries and Oceans
Pacific Biological Station
Nanaimo, BC, Canada
2005

Funded by the Herring Conservation and Research Society (HCRS)

The user's manual is intended to familiarize the client with the GUI and the process for setting new parameter values, modifying the input data file, saving and displaying results.

I. General Requirement

1. Recommended 600 MHz or higher CPU .
2. 128MB or more of RAM.

Note :This model was developed in 2003. The available data and parameter values at that time are for the period from 1951 to 2003. To perform simulations before 1951 or after 2003, the user must update the input file "dataFile.txt" and data file "ObsRec.txt" that contain observed tag recoveries.

II. General Processes

1. Copy input file "dataFile.txt" to the same folder as "TFDM.exe".
2. Copy file "ObsRec.txt" of observed tag recoveries to the same folder as"TFDM.exe".
3. Run the executable file "TFDM.exe"
4. Follow the GUI instructions for user specific settings or options. If no user specific settings are desired, click the run button at the bottom of the page. The default values from the input file "dataFile.txt" will be used directly.
5. Follow GUI instructions to display the results.

III. GUI Instructions

The following explanations of screen displays cover the process for 1) setting user specific parameter values if different from those in the default input file, 2) running the program, and 3) displaying the results.

1. TFDM Start-up

The initial user interface of TFDM is displayed in Figure 1. The interface has 9 functional components: Title bar, "Open Input Data File" frame, "Initial Settings" frame, "Modify Parameters" frame, "Prediction" frame, "Save Release-Recovery Data to File" frame, "RUN" button, "Visual Output" frame, and the display screen. All the frames are inactive except the "Save Release-Recovery Data to File" frame.

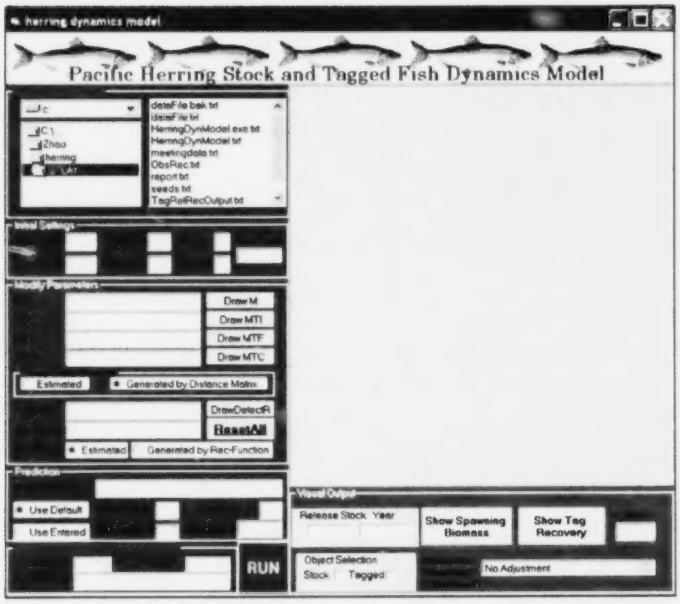

Figure 1. TFDM start-up graphical user interface

TFDM is an event-driven simulation program which means that mouse or keyboard activity will execute a certain section of computer code. Therefore the program has the inherent capability of enabling or disabling user interactive interface components in a logical order, allowing the user to organise the processes of execution. When a component is enabled, it is in an active state, ready to respond to a mouse or keyboard input event.

Most of the components provide tool tips to explain meaning or usage. Placing the mouse pointer over an active component brings up helpful operating instructions. The following are three examples (Figures 2, 3, and 4) of the tool tips.

Figure 2. Tool tip shows the options and meaning of the recruitment type index (RecType)

Figure 3. Tool tip directs user to retrieve and change values of the M text field

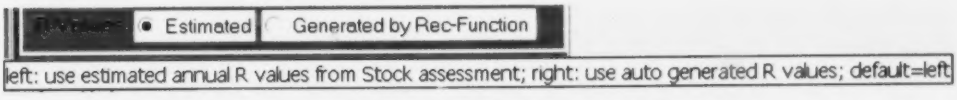
Estimated
Generated by Rec-Function
left: use estimated annual R values from Stock assessment; right: use auto generated R values; default=left

Figure 4. Tool tip explains options for using different recruitment types.

Figure 1. TFDM start-up graphical user interface

TFDM is an event-driven simulation program which means that mouse or keyboard activity will execute a certain section of computer code. Therefore the program has the inherent capability of enabling or disabling user interactive interface components in a logical order, allowing the user to organise the processes of execution. When a component is enabled, it is in an active state, ready to respond to a mouse or keyboard input event.

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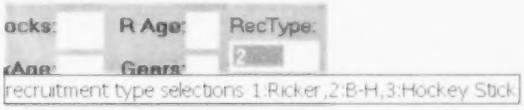

Figure 2. Tool tip shows the options and meaning of the recruitment type index (RecType)

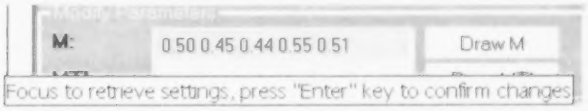

Figure 3. Tool tip directs user to retrieve and change values of the M text field

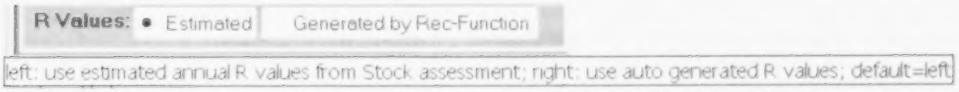
R Values:
Estimated
Generated by Rec-Function
left: use estimated annual R values from Stock assessment; right: use auto generated R values; default=left

Figure 4. Tool tip explains options for using different recruitment types.

1.1 Input Files

A default input file "dataFile.txt" should exist in the same folder as the executable TFDM file. The format of the file "dataFile.txt" is critical and cannot be changed. The general format is a comment line followed by a value for each parameter and an error check comment line if available. Each value is separated by a space (or tab) and there is no end of line (no carriage return) for each line of a data array. Appendix II shows the complete default wrapped data and format. The symbol "■"represents the end of a line.

The user can freely modify the input data file, however, the general format must be retained whenever a change is made to the file. Guidelines for modifications are:

1) No blank lines can be left among data, comment lines, and/or at the beginning of the file.
2) Comments can be modified, but existing complete lines cannot be deleted or new lines inserted.
3) Each value is separated by a space (including tab).
4) The error check line cannot be modified, including the leading symbol "", the space between the symbols, and "errorCheck_? ". The symbol "" is not available in the Microsoft Word editor, but the user can insert it with other plain text editing software, e.g., NotePad, EditPad, and Emacs.
5) A long line of data cannot be cut into short lines using the carriage return. The user may find the word wrap feature in a text viewer useful for viewing long lines of data.
6) If the values that determine array sizes (i.e., start year, end year, number of stocks, number of gears, recruitment age, and maximum age) are changed, the amount of data related to these values must also be changed to match the array size.
7) The user can insert spaces after "' errorCheck_11" to store old data values, include descriptions, or insert references.

The program will output error messages to help trace error location.

After the input file "dataFile.txt" has been selected by choosing the correct data path, a confirmation message will appear (Figure 5).

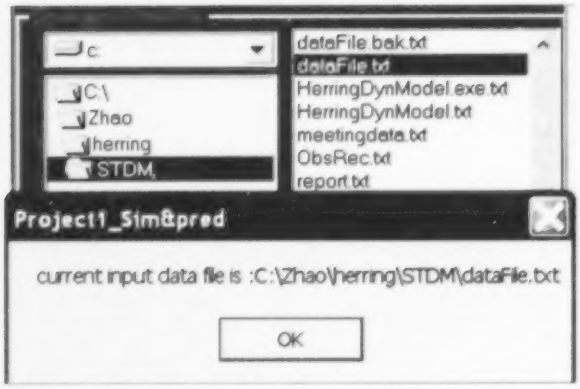

Figure 5. The input file at this location has been selected

TFDM will flag any errors in the default input file "dataFile.txt" by matching error checking points in the file (Figure 6).

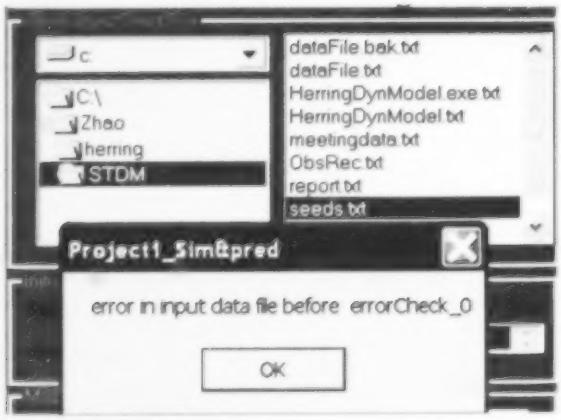

Figure 6. An error was detected in the input file.

An incorrect number of data values being input, an extra blank line in the file or a comment line being added or deleted will be detected between error check points 4 and 5, generating an error message (Figure 7).

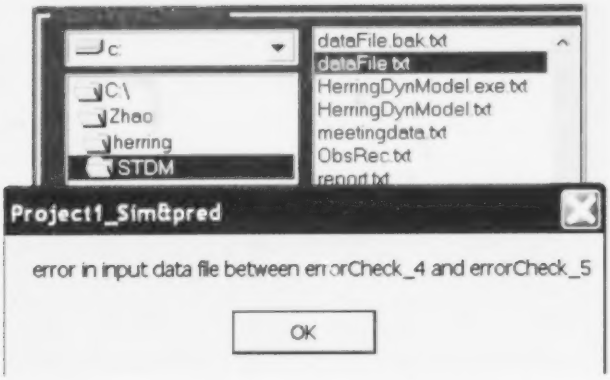

Figure 7. An error has been detected between check points 4 and 5.

An incorrect input file or any error in the input file will lead to the error message (Figure 8), after which the program will terminate.

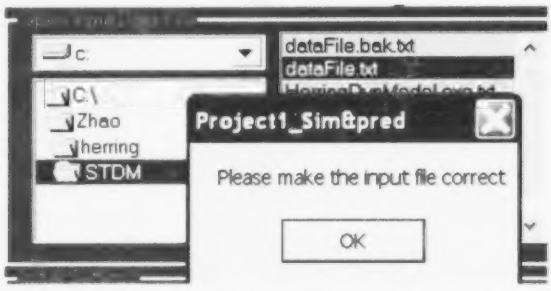

Figure 8. An error detected in the location or content of the input file

Another default input data file "ObsRec.txt" should also exist in the same folder as the "TFDM.exe" file, and contains the observed tag recoveries. The format of the file "ObsRec.txt" is shown in Appendix III. The observed tag recoveries from 1951 to 2003 are listed. The program will check the comment line for release year and stock to read data into a data array. Therefore the format of this file is critical and cannot be changed. The critical portion of the comment line, "'*1951,5", for example, is started with two delimiters "'*", followed by a 4 digit release year, a comma and then by a one digit release stock without any spaces before or among these characters. There are seven data columns, 0 to 6, representing recovery regions: 0=unknown region of tag recovery, 1=Queen Charlotte Islands, 2=Prince Rupert District, 3=Central Coast, 4=Johnstone Strait, 5=Strait of Georgia, 6=West Coast of Vancouver Island. Since the program is based on the current five-stock management system, any data from region 4 is ignored by the program during data input. The data in the unknown category are used by "ObsRecAdj" as explained in Section 3.3.

Users can append new data or modify recovery information corresponding to the appropriate sections in ObsRec.txt. If the range of years for simulation is in ObsRec.txt, the file does not need to be changed. Otherwise, extra data should be added into ObsRec.txt following the format in Appendix III exactly.

1.2 Initial Settings

The "Initial Settings" frame displays the essential simulation settings used for defining dimensions of various matrices. The default settings of the program are taken from the input file "dataFile.txt". The user can change the start year (StartYear), end year (EndYear) or the recruitment type (RecType) for the simulation. Other settings cannot be changed in this part of the interface and are inactive, although they can be changed in the data file.

The values of StartYear and EndYear must be within the range given in the input file. Figure 9 shows the error that occurs if the start year is set earlier than the default in the input file. The same error message is used when the end year is outside of the set range. The range of years appearing in the error message varies according to the settings in the input file.

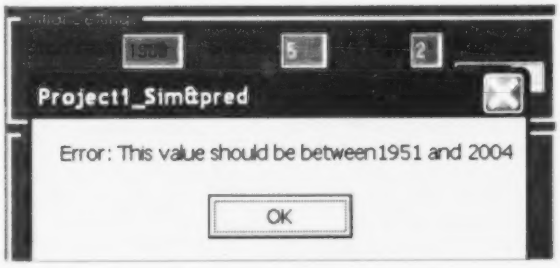

Figure 9. An error was detected in the range of years.

To change the value of the end year, the start year must be activated first, since the end year value must be verified against the start year.

The input text field will remain fixed until a correct value is input (Figure 10) . The error message is displayed as a reminder of the illegal value and to prompt entry of a valid year.

Figure 10. The text box for the start year stays fixed until a valid year is entered.

1.3 Modifying Parameters

In addition to modifying the input file directly, two other ways are provided in the GUI for modifying parameters. Parameters such as the: natural mortality rate (M); tag induced instantaneous mortality rate for belly tags (MTI), Floy tags (MTF), and CWTs (MTC); maximum stray rate (StrayMax); ratio of catch searched for tags (SearchR); tag detection rates and simulation replicates (replicate). The first method is to modify the parameter values with keyboard entries and then confirming the changes using a carriage return. The second method is to change the values by drawing a line of dots using the mouse pointer in the drawing pane (See the red lines in Figures 11 and 12). The steps for drawing a line are:

1) click on one of the "Draw M..." buttons and a blank graph will appear on the right.
2) move the mouse pointer to the graph, the pointer will display the Y axis value and reflect changes with movement. Position the pointer at the desired value in the vertical (Y) axis.
3) press the left mouse button to start drawing and do not release.
4) with left mouse button pressed, move pointer slowly across the graph to the right, a red dotted line will trace your movements.
5) stop moving pointer and release the left mouse button after all values are set.
6) click on the left text field and all the new values will appear in the text field.
7) If the user is not satisfied with the values, repeat steps 1 to 6.

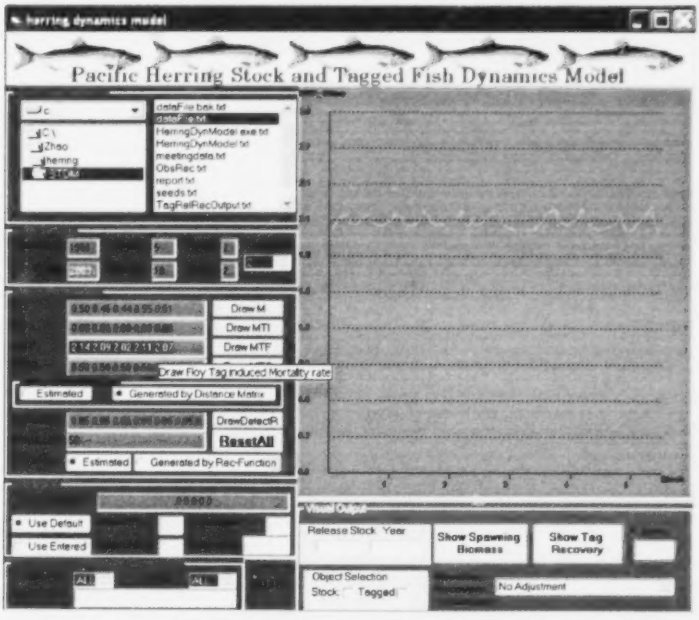

Figure 11. Using the drawing pane to modify parameters. The red dotted line is shown drawn for MTF and new data is displayed in the left text field of MTF.

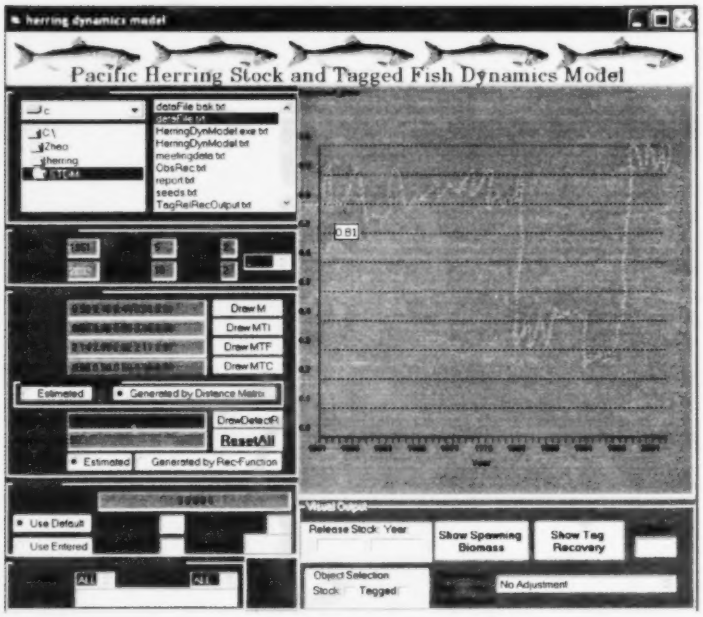

Figure 12. Using the drawing pane to modify parameters. Tag detection rates from 1951 to 2003 modified using the pointer to enter a tag detection scenario.

The drawing pane is a convenient way to enter new data, especially for large amounts of data input or to test some parameters in various new scenarios. Drawing should be slow enough to ensure that each X-axis mark is assigned a value by making the dots as close to the marks as possible.

The default simulation is conducted with 50 replicates, which means that the simulation will run 50 times using the same data set, but with different random deviations of some parameters. The run time is machine dependent, limited by the speed of the CPU and memory size. Typical run time for a Pentium 4, at 2.42GHz and 512MB of RAM is 9 seconds for 50 simulation replicates.

1.4 Options for Straying Rate and Recruitment

Two alternative assumptions for straying rates are shown in the "Stray Data Source" frame: one is to use default straying rates estimated based on historical tag recoveries (Zhao *et al.* in prep.), and the other is calculated using a distance matrix and population density dependent function following Ware and Schweigert (2001).

The two options for recruitment are labelled as "R Values". The default option is identified as "Estimated" and uses annual recruitment from the input file for all stocks ignoring any recruitment related parameter values. The second option is identified as "Generated by Rec-Function" and uses a recruitment function defined by "RecType". The default RecType is the Beverton-Holt (B-H) recruitment function. The Ricker or Hockey-stick recruitment functions are available in other options.

1.5 Prediction Feature

The TFDM software includes a prediction feature that estimates two types of tag recovery. The first predicts future tag recoveries of all tagged fish released in the previous few years and the second predicts future tag recoveries of fish planned to be tagged and released in the future years. The planned tag releases are taken from the "Tag Releases" text field in the "Prediction" frame for the five stocks, 1 to 5 respectively (Figure 13). Users may select default parameter values for the coming years by choosing the option "Use Default", or set specific values for the detection rate (DetectR_F), ratio of catch searched for tags (SearchR_F), tag induced instant mortality rate (InstantM) and harvest rates for all gear types (HarvestR). The ranges of all user input values are also checked for validity.

Figure 13. The number of tags planned to be released in the 5 stocks in the coming year.

1.6 File names and Settings for Output

Actual releases and simulated recoveries can be written to a file for future reference. Each set of results from each replication (i.e., 50 sets of results) will be saved when "Replicate" is set as the default. There are text fields that set release year, stock (region) and output file name in the frame of "Save Release-Recovery Data to File". The default values for the Year and Stock are "ALL" and the file name is "TagRelRecOutput.txt", which will be saved in the same directory as TFDM.exe. Users can specify another file name for the output of results along with the specified year and stock of estimated and observed tag recoveries. There are four strategies for saving results.

1) If both year and stock are set to "ALL", all observed and estimated tag recoveries will be saved to the result file.

2) If the year is set to a specific year and the stock is set to "ALL", all observed and estimated tag recoveries for that specific year of all stocks will be saved to the result file.

3) If the year is set to "ALL" and the stock is set to a specific stock, all observed and estimated tag recoveries of all years for that specific stock will be saved to the result file.

4) If both year and stock are specified, only the observed and estimated tag recoveries from the specific year and stock will be saved to the result file.

The results for each stock in all the simulated years are saved separately. For reference, the results of pre-fishery spawning biomass estimates are also saved in this text file, after tag recoveries.

2. The "RUN" command

After all settings are completed, clicking on the command button "RUN" executes the program. Users will notice that the pointer changes to an hourglass and a message appears on the graphic pane (Figure 14). TFDM is very CPU intensive and the program should not be interrupted. A progress bar provides an indicator of simulation status.

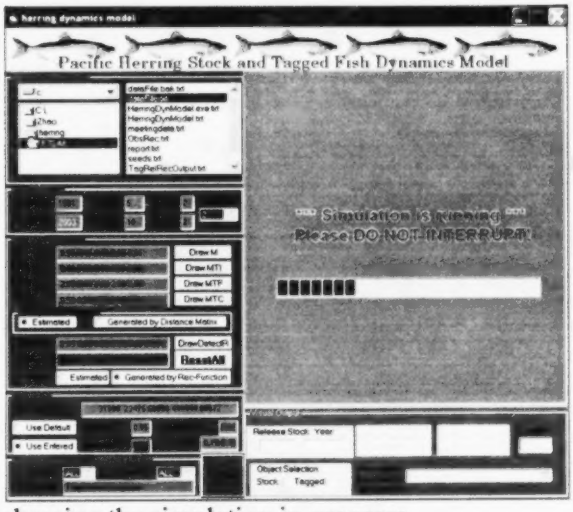

Figure 14. Status bar showing the simulation in progress.

3. Visual Output

After the program has completed the run, the visual output components become active (Figure 15).

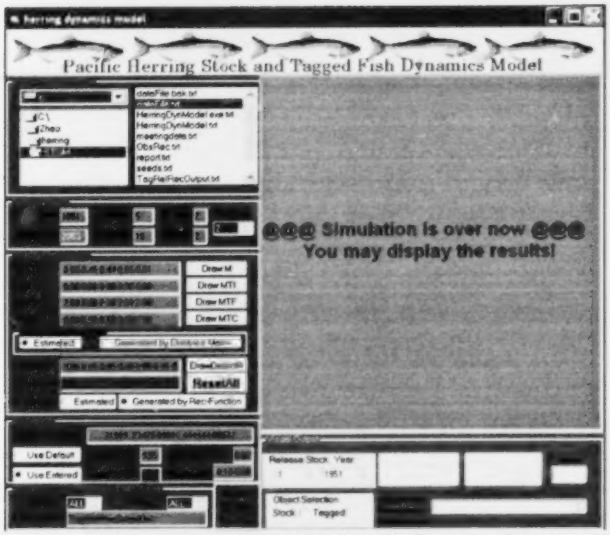

Figure 15. Output in the viewing pane after the simulation run is complete.

Users are able to view two objects: spawning biomass for the stock and tagged fish releases and recoveries.

3.1 Spawning Biomass Estimates

To display the spawning biomass estimates for a specific stock for the entire simulation period, follow these steps:

1) Click the list labelled "Release Stock" and select a number by clicking on it. Number must be highlighted
2) Click the check box labelled "Stock" in the "Object selection" frame.
3) The "Show Spawning Biomass" button should now be in an active state, click on it.
4) To show spawning biomass estimates for other stocks, repeat steps 1 to 3.

The trajectories for spawning biomass over all the simulations using the option "Generated by Rec-Function" and for the R values RecType = 2 (B-H recruitment function) are shown in Figure 16.

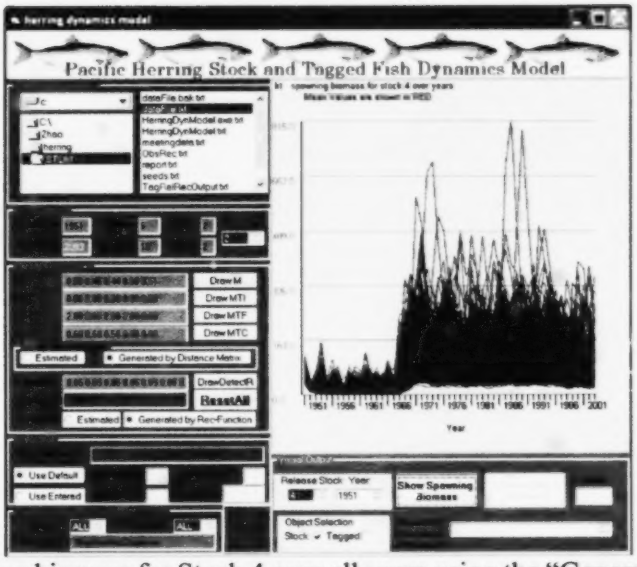

Figure 16. Spawning biomass for Stock 4 over all years using the "Generated by Rec-Function" option and B-H recruitment function (RecType=2) for recruitment estimates.

The total number of trajectories in Figure 16 are equal to the number of simulation replicates (replicates = 1000). The individual stock trajectories are presented by blue lines with the mean value shown by a red line. The units for spawning stock biomass is metric tonnes (kt). While the pane is in an active state, the pointer can be placed anywhere in the pane to display the value of spawning biomass in a particular year.

3.2 Comparison of the Estimated and Observed Tag Recoveries By Release

Historical tag release data are provided in the input file "dataFile.txt". Observed tag recoveries are provided in the file "ObsRec.txt" and is in the same directory as "dataFile.txt".

Only after the value of "Release Stock" and "Year" are set and the check box "Tagged" is selected, does the button for recovery "Show Tag Recovery" become active. At the same time, the "X-axis number" text box and "ObsRecAdj" list field also become active.

The "X-axis number" is used to set the X-axis units to be used. While the default setting is 10, it be can changed in the range of 2 to 20.

In some years, there are observed recoveries with an unknown recovery region (stock). The "ObsRecAdj" provides three options to deal with unknown region data. Option 1 is to ignore the unknown data (No Adjustment). Option 2 is to add all of the unknown data to the release stock for that year (To RelStk Only). Option 3 is to distribute the unknown data into all stocks of that year according to the straying matrix (On StrayMatrix).

TFDM provides a simple means to compare the simulated tag recoveries with the observed values. Users also have the option to make adjustments to the parameter values in the input file to improve the fit to the data.

To view the simulated recoveries in the viewing pane, follow these steps.

1) Select a release stock and year from the list, the background colour should change to dark blue in both text fields.
2) Select the "Tagged" check box in the "Object selection" frame and the "Show Tag Recovery" button should become activated.
3) Click "Show Tag Recovery" and a graph (Figure 17) is displayed using the default settings for the X-axis (default = 10) and the ObsRecAdj (default = "No Adjustment").
4) For best results, users can reset the X-axis to a number in the range of 2 to 20 or the ObsRecAdj to one of the three options at anytime, then click on the "Show Tag Recovery" button.
5) All possible recoveries are shown in the small viewing panes. To enlarge, double click the left mouse button while the mouse pointer is on the small pane.
6) Double click on the enlarged picture pane to return back to its original size,.
7) Repeat steps 1 to 6 to view other tag release and recovery results for a different stock and year.
8) Users can now set new parameter values and rerun the program.

Figure 17 displays one of the predicted recoveries from a tag release event in the coming year, which shows no actual observed recoveries, with both the release year and the recovery years in the future. Parameter values for the prediction period are set at their default settings.

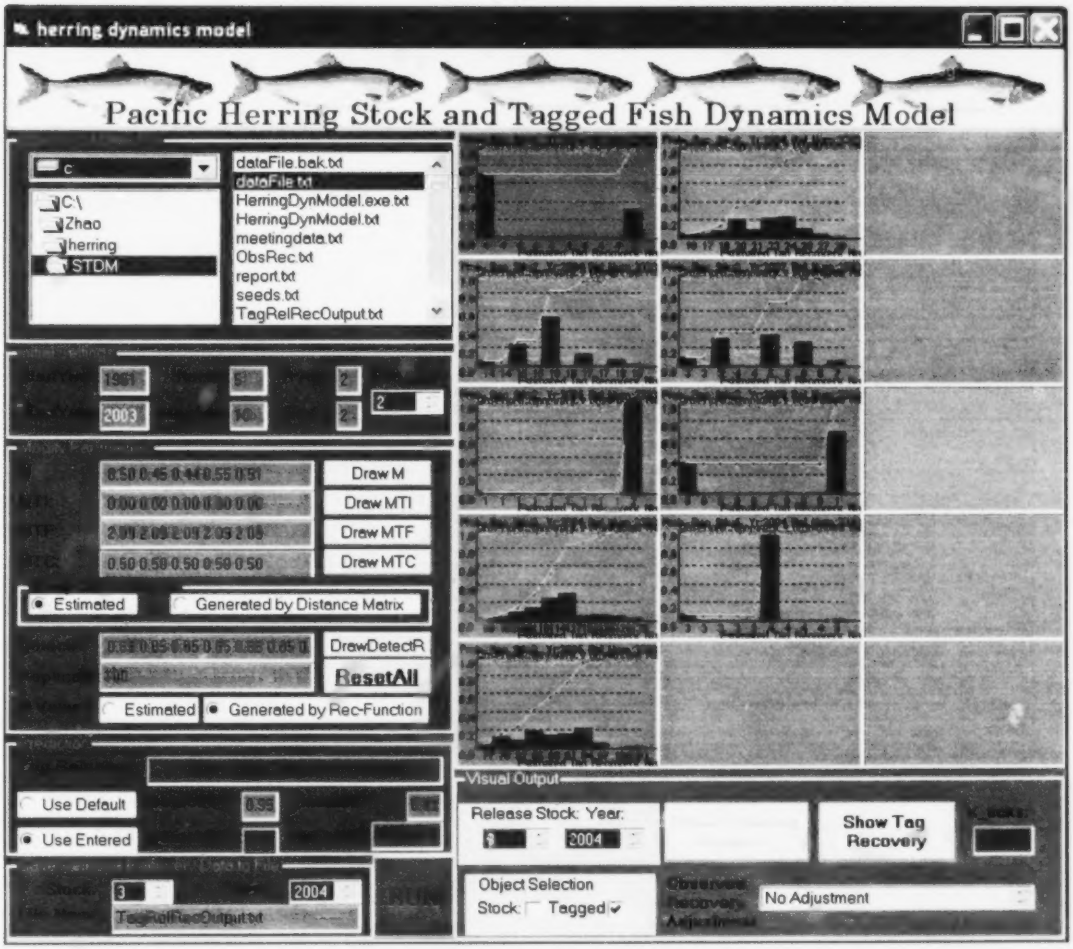

Figure 17. Graphical display of tag releases and recoveries for the year 2004 for Stock 3 with individual viewing panes.

A magnified version of the panel for the recoveries in Stock 3 and year 2006 from the release event in Stock 3 in the year 2004 is shown in Figure 18.

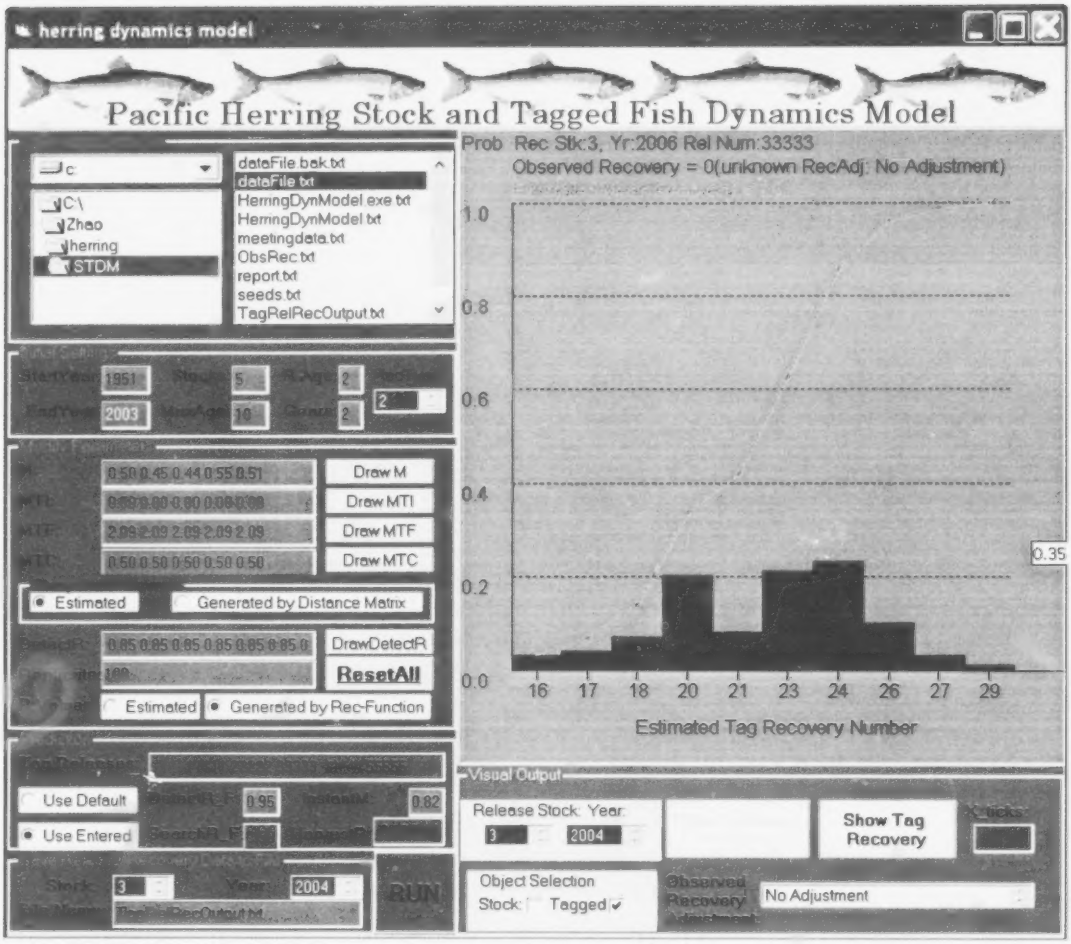

Figure 18. Predicted 2006 tag recoveries in Stock 3 from a future release event in 2004 and Stock 3.

Appendix II. The input file "dataFile.txt"

```
'Default simulation replicate■
        50■
'Start Year (stYr) of the simulation■
        1951■
'End Year (endYr) of the simulation■
        2003■
'Number of stocks (Nstocks)  (5 fishery and management regions in this model) ■
        5■
'Max age of simulation (maxAge)■
        10■
"Recuitment age(recAge)■
        2■
'Nnumber of fishing gears (Ngears) (order: seine, gillnet for herring in this model) ■
        2■
' errorCheck_0■
'sigmaR_projection (recruitment function coefficient) ■
        0.6■
'rhoR_projection (recruitment function coefficient) ■
        0.4■
'CV_M (natural mortility rate variance) ■
        0.2■
'CV_MTI (instantaneous belly tag induced mortality rate variance) ■
        0.2■
'CV_MTF (instantaneous Floy@ anchor tag induced mortality rate variance) ■
        0.2■
'CV_MTC (instantaneous CWT induced mortality rate variance) ■
        0.2■
'CV_Init (Initial recruitment variance)■
        0.2■
'CV_maturity (maturity variance)■
        0.1■
'CV_comp (Gear selectivity variance) ■
        0.05■
'CV_sel_a50 (Gear 50% selectivity  variance) ■
        0.1■
'Default recruitment function(SR_Type ) for generating R from  1:Ricker,2:B-H,3:Hockey■
        2■
'Distance among Nstocks. Row= stock (1 to Nstocks), rol = stock (1 to Nstocks)  from Ware and Schweigert (2001)■
        0       197     202     622     596■
        197     0       303     776     713■
        202     303     0       434     447■
        622     776     434     0       274■
        596     713     447     274     0■
' errorCheck_1■
'Initial recruitment (Rzero_stk) for Nstocks,   in million fish■
        111.854  190.687  181.521  682.789  331.644 ■
'Natural mortality rate (M_stk) of Nstocks, from Fu et al (2003)■
        0.4985   0.4497  0.4374  0.5451  0.5060■
'Tag induced instantaneous mortality rate of belly tag (MTI)_for Nstocks from Zhao et al (2004) ■
        0.0000  0.0000  0.0000  0.0000  0.0000■
'Tag induced instantaneous mortality rate of Floy tag  (MTF)_for Nstocks from Zhao et al (2004) ■
        2.0893  2.0893  2.0893  2.0893  2.0893 ■
'Tag induced instantaneous mortality rate of CWT (MTC)_for Nstocks from Zhao et al (2004)■
        0.4971  0.4971  0.4971  0.4971  0.4971■
'Tag induced Instant Mortality rates (TIM_yr ) of stYr to endYr (Zhao et al, 2004)■
        0.9067  0.9149  0.9429  0.8655  0.9786  0.9862  0.8589  0.9945  0.0000  0.0000  0.0000
        0.0000  0.0000  0.8040  0.7088  0.8756  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
        0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.5198  0.8395  0.0000  0.2287  0.5848
        0.0000  0.8041  0.4871  0.0000  0.5695  0.7068  0.6316  0.3661  0.0000  0.0000  0.0000
        0.0000  0.0000  0.0000  0.0000  0.7349  0.8904  0.8259  0.7012  0.9237■
'h_stock: recruitment coefficients to the initial stock biomass■
        0.8  0.8  0.8  0.8  0.8■
```

'delta_stock: recruitment coefficients of related to the smoothness■
0.2 0.2 0.2 0.2 0.2■
' errorCheck_2■
''QCI (stk 1) exploitation rates from Fu et al (2003), row=gear(1, Ngears); col=year (stYr to endYr) ■
0.5309 0.6738 0.0001 0.0973 0.0406 0.8422 0.8748 0.4306 0.5603 0.0001 0.0450
0.3326 0.3902 0.7567 0.8933 0.7053 0.2793 0.0436 0.0004 0.0002 0.0111 0.2487
0.3853 0.0046 0.0026 0.0534 0.0559 0.1167 0.1355 0.0393 0.0480 0.0455 0.0395
0.0240 0.0882 0.0850 0.1408 0.1284 0.2796 0.0706 0.0491 0.2137 0.3485 0.1817
0.0002 0.0002 0.0236 0.1789 0.3208 0.3273 0.0450 0.4650 0.2911■
0.0002 0.0001 0.0002 0.0001 0.0001 0.0000 0.0001 0.5661 0.0003 0.0002 0.0001
0.0001 0.0000 0.0000 0.0001 0.0004 0.0020 0.0015 0.0009 0.0005 0.0002 0.0001
0.1259 0.3402 0.4800 0.2826 0.5894 0.5603 0.2893 0.5924 0.4021 0.2137 0.1863
0.3670 0.2454 0.2620 0.0001 0.0001 0.0001 0.4249 0.0002 0.0001 0.0001 0.0002
0.0004 0.0003 0.0002 0.0001 0.0927 0.0002 0.0002 0.0004 0.0005■
'PR (stk 2) exploitation rates from Fu et al (2003), row=gear(1, Ngears); col=year (stYr to endYr) ■
0.4618 0.8662 0.0791 0.7737 0.5892 0.2274 0.6800 0.1350 0.2969 0.3012 0.5532
0.4443 0.4410 0.4255 0.8277 0.7805 0.6519 0.2999 0.0003 0.0929 0.2534 0.5407
0.1807 0.1698 0.0959 0.2487 0.3301 0.3145 0.3674 0.1890 0.2062 0.1329 0.0354
0.0728 0.0910 0.1284 0.0889 0.1179 0.1346 0.1273 0.0818 0.0649 0.0970 0.1341
0.0834 0.0367 0.0314 0.0310 0.0511 0.0821 0.0706 0.1251 0.1074■
0.0000 0.0000 0.0001 0.0000 0.0000 0.0001 0.0000 0.0001 0.0001 0.0000 0.0000
0.0000 0.0000 0.0000 0.1897 0.0001 0.0003 0.0004 0.0007 0.0003 0.0001 0.0001
0.0001 0.1967 0.0001 0.0175 0.0967 0.1880 0.1566 0.2012 0.0750 0.0001 0.0001
0.1237 0.1530 0.1631 0.1961 0.2696 0.3026 0.1541 0.1595 0.2939 0.2793 0.1427
0.0978 0.2526 0.4440 0.2203 0.1291 0.1633 0.2527 0.1957 0.2440■
'CC (stk 3) exploitation rates from Fu et al (2003), row=gear(1, Ngears); col=year (stYr to endYr) ■
0.5882 0.9035 0.1154 0.4646 0.2493 0.7672 0.8217 0.3453 0.6352 0.0940 0.7006
0.2730 0.9050 0.7129 0.6596 0.7597 0.7960 0.1903 0.0002 0.0122 0.1996 0.4196
0.2852 0.1414 0.0973 0.1549 0.1350 0.2418 0.0163 0.0041 0.0114 0.0678 0.0759
0.1485 0.1490 0.1261 0.1594 0.0961 0.1434 0.1500 0.2484 0.1511 0.1612 0.2125
0.2749 0.1812 0.1316 0.2088 0.1780 0.2263 0.2444 0.1704 0.1505■
0.0000 0.0000 0.0002 0.0001 0.0000 0.0000 0.0001 0.0001 0.0001 0.0000 0.0000
0.0000 0.0000 0.0000 0.0001 0.0001 0.0002 0.0004 0.0006 0.0003 0.0001 0.0150
0.0754 0.4768 0.2946 0.2860 0.3129 0.5543 0.0002 0.1334 0.1002 0.1025 0.1429
0.1836 0.1471 0.0784 0.0774 0.0812 0.1729 0.1191 0.0800 0.0510 0.0758 0.0546
0.0546 0.0250 0.0278 0.0452 0.0664 0.0413 0.0174 0.0294 0.0826■
'SG (stk 4) exploitation rates from Fu et al (2003), row=gear(1, Ngears); col=year (stYr to endYr) ■
0.7620 0.6167 0.0894 0.7803 0.4573 0.6502 0.7991 0.5688 0.5277 0.6560 0.5717
0.6898 0.6203 0.7643 0.5326 0.7643 0.8359 0.1546 0.0001 0.0069 0.0427 0.2632
0.2384 0.0172 0.0167 0.0864 0.1196 0.1856 0.1967 0.0371 0.0921 0.0847 0.1278
0.1523 0.1127 0.0121 0.0788 0.0455 0.0388 0.0032 0.0281 0.0644 0.0555 0.0703
0.0686 0.1111 0.1366 0.0773 0.0726 0.0789 0.0825 0.0844 0.1123■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0060 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0001 0.0003 0.0002 0.0001 0.0001 0.0163
0.1401 0.2121 0.1856 0.2437 0.2126 0.2740 0.1672 0.0858 0.1063 0.1166 0.2597
0.2889 0.3545 0.0000 0.2937 0.2762 0.2837 0.2088 0.3275 0.2824 0.1806 0.2431
0.1959 0.1712 0.2672 0.3147 0.1591 0.2561 0.2346 0.2492 0.0000■
'WCVI (stk 5) exploitation rates from Fu et al (2003), row=gear(1, Ngears); col=year (stYr to endYr) ■
0.3793 0.9562 0.0005 0.7830 0.1305 0.3447 0.0292 0.0052 0.7743 0.8553 0.6991
0.5458 0.6116 0.5933 0.6123 0.7167 0.7752 0.0001 0.0001 0.0000 0.0000 0.1606
0.4390 0.1756 0.2434 0.2859 0.2492 0.1194 0.1802 0.0302 0.0906 0.0562 0.2443
0.2290 0.0076 0.0054 0.3406 0.1906 0.1934 0.1989 0.1894 0.1091 0.1572 0.1645
0.1104 0.0586 0.1747 0.1426 0.1735 0.1076 0.0252 0.0451 0.0811■
0.0000 0.0000 0.0001 0.0000 0.0001 0.0000 0.0000 0.0000 0.0017 0.0000 0.0001
0.0001 0.0000 0.0000 0.0001 0.0001 0.0002 0.0003 0.0002 0.0001 0.0001 0.0000
0.0462 0.0847 0.1775 0.3075 0.1891 0.4465 0.2307 0.1016 0.1285 0.1236 0.1466
0.0847 0.0001 0.0000 0.0970 0.0815 0.1149 0.0743 0.1008 0.0337 0.0000 0.0270
0.0000 0.0001 0.0001 0.1307 0.0729 0.0880 0.0001 0.0518 0.1805■
' errorCheck_3■
'Maturity at age. row=stock(1 to Nstocks), col=age (recAge to maxAge)■
0.03 0.94 1. 1. 1. 1. 1. 1. 1.■
0.03 0.94 1. 1. 1. 1. 1. 1. 1.■
0.03 0.94 1. 1. 1. 1. 1. 1. 1.■
0.03 0.94 1. 1. 1. 1. 1. 1. 1.■
0.03 0.94 1. 1. 1. 1. 1. 1. 1.■

'Age composition of from herring database. row=stock,(1 to Nstocks){age(recAge to maxAge)}, col=year (stYr to endYr)■

0.0010 0.1712 0.0130 0.0300 0.0870 0.0010 0.2080 0.8198 0.0800 0.1622 0.0420 0.0300 0.0040
0.0090 0.0160 0.1838 0.0090 0.3000 0.7347 0.0000 0.0650 0.0301 0.0020 0.0010 0.0060 0.0040
0.0010 0.0020 0.0560 0.0050 0.0020 0.0080 0.0490 0.0210 0.0130 0.0020 0.0170 0.0360 0.0230
0.0020 0.0669 0.0070 0.0030 0.0619 0.1413 0.1080 0.2260 0.0030 0.0350 0.0500 0.1172 0.1998
0.0202■
0.1530 0.2182 0.3836 0.2897 0.1410 0.1603 0.2410 0.1642 0.6280 0.3524 0.3263 0.3764 0.5000
0.1532 0.7980 0.3277 0.6723 0.5060 0.2309 0.3600 0.5040 0.3267 0.4052 0.3047 0.2533 0.0280
0.1958 0.2617 0.0440 0.8303 0.0350 0.0451 0.0519 0.3530 0.1491 0.0280 0.1040 0.5095 0.1750
0.0961 0.0410 0.3850 0.0340 0.0430 0.1693 0.5390 0.2620 0.5325 0.0220 0.1848 0.3277 0.2338
0.4263■
0.5290 0.3423 0.2048 0.2128 0.3940 0.0962 0.1580 0.0120 0.1420 0.4254 0.3604 0.4144 0.2710
0.5956 0.1100 0.1638 0.2647 0.1720 0.0305 0.2450 0.2930 0.3838 0.2156 0.4036 0.3423 0.3730
0.0799 0.1728 0.3160 0.0449 0.8500 0.0441 0.0350 0.0490 0.3183 0.2202 0.0590 0.0749 0.6630
0.1822 0.1069 0.0490 0.6036 0.0500 0.0190 0.0930 0.3340 0.2817 0.6474 0.0390 0.2204 0.2488
0.2717■
0.1530 0.2153 0.2557 0.3367 0.1810 0.6232 0.0960 0.0020 0.0620 0.0290 0.2483 0.0961 0.1820
0.1782 0.0440 0.1039 0.0270 0.0220 0.0039 0.2200 0.0800 0.1603 0.2725 0.1768 0.2793 0.2940
0.2937 0.0949 0.1870 0.0539 0.0540 0.8478 0.0689 0.0280 0.0400 0.4024 0.2440 0.0480 0.0400
0.6007 0.2867 0.0840 0.0440 0.4835 0.0471 0.0320 0.0520 0.1188 0.1698 0.5904 0.0611 0.1309
0.1313■
0.1150 0.0410 0.1329 0.1018 0.1480 0.0842 0.2670 0.0010 0.0170 0.0150 0.0130 0.0651 0.0210
0.0530 0.0210 0.0749 0.0270 0.0000 0.0000 0.1330 0.0430 0.0611 0.0797 0.0909 0.0951 0.2270
0.2298 0.2617 0.2130 0.0279 0.0310 0.0240 0.7282 0.1050 0.0450 0.0400 0.3780 0.1179 0.0160
0.0390 0.3845 0.1250 0.0611 0.1059 0.3918 0.0330 0.0150 0.0290 0.0808 0.0798 0.2234 0.0320
0.0697■
0.0420 0.0110 0.0100 0.0190 0.0440 0.0271 0.0250 0.0010 0.0240 0.0070 0.0040 0.0160 0.0200
0.0110 0.0090 0.0589 0.0000 0.0000 0.0000 0.0210 0.0080 0.0240 0.0170 0.0190 0.0190 0.0630
0.1508 0.1409 0.1510 0.0190 0.0180 0.0160 0.0390 0.4280 0.1141 0.0330 0.0380 0.1487 0.0390
0.0180 0.0370 0.3070 0.1211 0.1089 0.0872 0.1560 0.0440 0.0070 0.0270 0.0450 0.0342 0.1357
0.0273■
0.0060 0.0010 0.0000 0.0070 0.0030 0.0070 0.0040 0.0000 0.0210 0.0070 0.0020 0.0020 0.0000
0.0000 0.0020 0.0490 0.0000 0.0000 0.0000 0.0210 0.0050 0.0090 0.0080 0.0030 0.0040 0.0100
0.0450 0.0530 0.0280 0.0120 0.0070 0.0090 0.0160 0.0100 0.3155 0.0801 0.0430 0.0140 0.0280
0.0380 0.0180 0.0240 0.1172 0.1078 0.0731 0.0240 0.0540 0.0130 0.0070 0.0040 0.0120 0.0140
0.0364■
0.0010 0.0000 0.0000 0.0020 0.0010 0.0000 0.0010 0.0000 0.0130 0.0020 0.0040 0.0000 0.0010
0.0000 0.0000 0.0210 0.0000 0.0000 0.0000 0.0000 0.0020 0.0040 0.0000 0.0010 0.0010 0.0010
0.0040 0.0100 0.0040 0.0060 0.0020 0.0050 0.0090 0.0040 0.0040 0.1913 0.0580 0.0170 0.0060
0.0170 0.0400 0.0060 0.0120 0.0320 0.0472 0.0120 0.0090 0.0110 0.0050 0.0050 0.0030 0.0040
0.0141■
0.0000 0.0000 0.0000 0.0010 0.0010 0.0010 0.0000 0.0000 0.0130 0.0000 0.0000 0.0000 0.0010
0.0000 0.0000 0.0170 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0000 0.0000
0.0000 0.0030 0.0010 0.0010 0.0010 0.0010 0.0030 0.0020 0.0010 0.0030 0.0590 0.0340 0.0100
0.0070 0.0190 0.0130 0.0040 0.0070 0.0240 0.0030 0.0040 0.0040 0.0060 0.0020 0.0010 0.0010
0.0030■
0.0430 0.0480 0.0120 0.0210 0.0270 0.1000 0.1150 0.0230 0.0340 0.6020 0.0971 0.0300 0.3926
0.0370 0.0650 0.3932 0.5720 0.3490 0.3003 0.1870 0.0934 0.0000 0.0030 0.0020 0.0130 0.0000
0.0010 0.0110 0.0270 0.0060 0.0050 0.0270 0.0140 0.0050 0.0020 0.0180 0.0090 0.0050 0.0060
0.0070 0.0090 0.0040 0.0010 0.0070 0.0320 0.0110 0.0090 0.0020 0.0100 0.0190 0.0190 0.0649
0.0030■
0.1822 0.0881 0.3814 0.2840 0.0490 0.5810 0.1780 0.2200 0.5894 0.0710 0.5836 0.3033 0.1329
0.6496 0.1400 0.2417 0.3220 0.3970 0.4505 0.6290 0.4559 0.0531 0.3293 0.1788 0.0939 0.0080
0.1600 0.1170 0.1818 0.7790 0.1119 0.1880 0.2080 0.3550 0.0780 0.1379 0.3860 0.3093 0.2170
0.1818 0.4795 0.3984 0.1071 0.0490 0.1528 0.6400 0.1840 0.3320 0.0551 0.2800 0.4240 0.1998
0.4995■
0.5856 0.3373 0.2302 0.2910 0.7030 0.0950 0.3980 0.0570 0.2038 0.2270 0.0731 0.4474 0.1818
0.1011 0.5260 0.0973 0.0540 0.1940 0.2062 0.1510 0.2936 0.1792 0.0439 0.5315 0.2218 0.0690
0.0370 0.3280 0.1149 0.0730 0.8111 0.0740 0.1770 0.1440 0.5470 0.0939 0.1020 0.3904 0.3610
0.2258 0.0949 0.3724 0.4434 0.1340 0.0679 0.0980 0.5620 0.2200 0.4108 0.0960 0.2110 0.3387
0.1201■
0.1041 0.4525 0.2543 0.2400 0.1560 0.1900 0.1320 0.0660 0.0519 0.0600 0.1802 0.0691 0.2197
0.1091 0.0810 0.1705 0.0190 0.0460 0.0390 0.0310 0.0883 0.6446 0.3034 0.0739 0.4306 0.3170
0.2270 0.0960 0.2917 0.0510 0.0330 0.6630 0.0530 0.1030 0.1190 0.4625 0.0690 0.0591 0.2770

0.2817 0.1259 0.0591 0.3025 0.4870 0.1129 0.0320 0.0860 0.3630 0.2034 0.2830 0.0550 0.1948
0.1742■
0.0561 0.0611 0.1111 0.1320 0.0520 0.0260 0.1600 0.0070 0.0869 0.0240 0.0430 0.0992 0.0360
0.0892 0.0970 0.0441 0.0270 0.0070 0.0020 0.0000 0.0472 0.0591 0.2655 0.1648 0.1119 0.5010
0.3780 0.2110 0.1149 0.0380 0.0170 0.0280 0.4920 0.1440 0.0640 0.1079 0.2990 0.0831 0.0490
0.2047 0.1578 0.0531 0.0400 0.2260 0.4316 0.0460 0.0310 0.0440 0.2475 0.1250 0.1550 0.0440
0.1001■
0.0260 0.0100 0.0100 0.0260 0.0110 0.0050 0.0140 0.0270 0.0140 0.0120 0.0160 0.0340 0.0300
0.0070 0.0790 0.0362 0.0040 0.0030 0.0020 0.0010 0.0154 0.0380 0.0339 0.0440 0.0958 0.0730
0.1500 0.2040 0.1828 0.0350 0.0150 0.0140 0.0370 0.2360 0.1060 0.0529 0.0590 0.1161 0.0450
0.0400 0.0949 0.0670 0.0440 0.0410 0.1578 0.1110 0.0540 0.0140 0.0442 0.1650 0.0670 0.0989
0.0340■
0.0030 0.0030 0.0010 0.0060 0.0020 0.0020 0.0030 0.0000 0.0190 0.0020 0.0060 0.0090 0.0050
0.0060 0.0080 0.0120 0.0020 0.0010 0.0000 0.0010 0.0052 0.0240 0.0130 0.0030 0.0250 0.0240
0.0330 0.0240 0.0649 0.0130 0.0040 0.0040 0.0110 0.0100 0.0820 0.0709 0.0350 0.0190 0.0360
0.0330 0.0170 0.0340 0.0430 0.0370 0.0240 0.0570 0.0510 0.0110 0.0100 0.0230 0.0590 0.0380
0.0430■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0010 0.0020 0.0010 0.0050 0.0010
0.0010 0.0030 0.0050 0.0000 0.0030 0.0000 0.0000 0.0010 0.0010 0.0080 0.0020 0.0060 0.0080
0.0090 0.0060 0.0140 0.0040 0.0020 0.0020 0.0060 0.0020 0.0010 0.0550 0.0290 0.0140 0.0060
0.0220 0.0090 0.0060 0.0160 0.0140 0.0130 0.0030 0.0210 0.0130 0.0090 0.0050 0.0090 0.0180
0.0160■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0030 0.0010
0.0000 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0020 0.0000
0.0050 0.0030 0.0080 0.0010 0.0010 0.0000 0.0020 0.0010 0.0010 0.0010 0.0120 0.0040 0.0030
0.0040 0.0120 0.0060 0.0030 0.0050 0.0080 0.0020 0.0020 0.0010 0.0100 0.0040 0.0010 0.0030
0.0100■
0.0240 0.0521 0.0940 0.0400 0.0670 0.1692 0.1672 0.2448 0.0380 0.4346 0.1610 0.0970 0.0040
0.1310 0.0820 0.6737 0.3740 0.3250 0.3220 0.5400 0.2690 0.0440 0.0120 0.0280 0.0120 0.0300
0.0070 0.0020 0.0570 0.0370 0.0200 0.0170 0.0050 0.0440 0.0270 0.0390 0.0410 0.0110 0.0130
0.0100 0.0200 0.0200 0.0289 0.0120 0.0080 0.1160 0.0210 0.0050 0.0070 0.0040 0.0240 0.0340
0.0040■
0.2857 0.2012 0.2810 0.6927 0.0770 0.1361 0.5075 0.6104 0.4865 0.2318 0.3220 0.5740 0.3027
0.4740 0.3640 0.2042 0.4620 0.4800 0.2770 0.4440 0.3580 0.2977 0.5045 0.1770 0.3297 0.1181
0.1742 0.2570 0.0440 0.7310 0.1231 0.1558 0.0701 0.0730 0.3750 0.1640 0.2260 0.6790 0.0460
0.0569 0.1878 0.5846 0.0669 0.2128 0.0609 0.1960 0.5670 0.3630 0.0879 0.1910 0.0780 0.2973
0.4000■
0.5065 0.3013 0.2400 0.2053 0.7460 0.0921 0.1081 0.1208 0.3774 0.2647 0.1080 0.1790 0.5794
0.2770 0.3380 0.0731 0.1310 0.1700 0.2670 0.0120 0.2980 0.2767 0.1858 0.3860 0.2547 0.4124
0.2262 0.1520 0.3150 0.0640 0.6667 0.1069 0.1542 0.1010 0.0750 0.4020 0.1460 0.1170 0.7620
0.0500 0.0679 0.1141 0.6407 0.0849 0.2318 0.0580 0.1690 0.4240 0.4256 0.1080 0.2740 0.1021
0.2140■
0.1199 0.3814 0.2660 0.0460 0.0910 0.5706 0.0621 0.0130 0.0831 0.0559 0.2970 0.0260 0.0539
0.1030 0.1580 0.0360 0.0200 0.0210 0.1130 0.0040 0.0310 0.2567 0.1548 0.1970 0.2777 0.2092
0.3183 0.1990 0.1870 0.0900 0.0841 0.6014 0.1081 0.1820 0.0860 0.0860 0.3220 0.0630 0.0920
0.7253 0.0619 0.0270 0.0968 0.5295 0.0939 0.1670 0.0360 0.0850 0.3427 0.3470 0.1190 0.1812
0.0770■
0.0509 0.0450 0.1020 0.0130 0.0150 0.0290 0.1481 0.0060 0.0070 0.0110 0.1010 0.0990 0.0290
0.0140 0.0540 0.0110 0.0100 0.0030 0.0200 0.0000 0.0330 0.0689 0.1169 0.1340 0.0859 0.1683
0.1662 0.2310 0.2130 0.0400 0.0701 0.0519 0.5716 0.1610 0.1310 0.0630 0.0570 0.0710 0.0360
0.0748 0.5554 0.0340 0.0200 0.0748 0.4795 0.0680 0.0610 0.0240 0.0648 0.2620 0.2570 0.0621
0.1080■
0.0120 0.0150 0.0130 0.0020 0.0040 0.0030 0.0070 0.0050 0.0040 0.0010 0.0090 0.0240 0.0290
0.0010 0.0030 0.0020 0.0020 0.0000 0.0010 0.0000 0.0080 0.0440 0.0190 0.0660 0.0320 0.0450
0.0851 0.1090 0.1510 0.0260 0.0260 0.0460 0.0500 0.4070 0.1190 0.0670 0.0450 0.0170 0.0280
0.0380 0.0640 0.1883 0.0259 0.0200 0.0649 0.3060 0.0400 0.0310 0.0170 0.0580 0.1910 0.2152
0.0490■
0.0010 0.0040 0.0040 0.0000 0.0000 0.0000 0.0000 0.0000 0.0040 0.0010 0.0010 0.0010 0.0020
0.0000 0.0010 0.0000 0.0010 0.0010 0.0000 0.0000 0.0020 0.0110 0.0050 0.0090 0.0070 0.0150
0.0190 0.0350 0.0280 0.0070 0.0060 0.0150 0.0310 0.0230 0.1820 0.0610 0.0580 0.0150 0.0070
0.0300 0.0230 0.0210 0.1048 0.0280 0.0290 0.0600 0.0850 0.0300 0.0220 0.0120 0.0420 0.0901
0.1030■
0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0010 0.0020 0.0030 0.0010 0.0020
0.0040 0.0110 0.0040 0.0040 0.0030 0.0050 0.0070 0.0080 0.0040 0.1130 0.0470 0.0150 0.0080

0.0070 0.0150 0.0060 0.0110 0.0350 0.0230 0.0150 0.0150 0.0300 0.0200 0.0090 0.0090 0.0150
0.0380■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0040 0.0010 0.0010 0.0010 0.0010 0.0030 0.0010 0.0010 0.0050 0.0580 0.0120 0.0080
0.0080 0.0050 0.0050 0.0050 0.0030 0.0180 0.0140 0.0060 0.0080 0.0130 0.0090 0.0060 0.0030
0.0070■
0.0420 0.1119 0.0950 0.0140 0.0460 0.0699 0.0110 0.0850 0.1441 0.0780 0.3193 0.0930 0.1688
0.0589 0.1510 0.1950 0.3686 0.3040 0.6200 0.2560 0.2031 0.0731 0.0380 0.1483 0.0369 0.1201
0.0423 0.0080 0.0160 0.0250 0.0691 0.0629 0.0300 0.0809 0.2392 0.1260 0.0929 0.0440 0.1000
0.0790 0.0941 0.0511 0.1520 0.0470 0.0900 0.1299 0.0790 0.0410 0.0641 0.1010 0.0691 0.0759
0.0357■
0.5656 0.5534 0.5600 0.5265 0.5020 0.3506 0.6557 0.5510 0.6617 0.5140 0.2753 0.7060 0.5145
0.6044 0.5590 0.3830 0.4565 0.5060 0.2710 0.6030 0.3785 0.3644 0.5110 0.4830 0.5479 0.2482
0.5121 0.3530 0.2000 0.4980 0.3704 0.3467 0.3137 0.3776 0.4384 0.5620 0.3317 0.6010 0.1800
0.5720 0.2172 0.5485 0.3780 0.4216 0.2180 0.4835 0.5210 0.4745 0.2482 0.3780 0.4414 0.4955
0.3833■
0.3033 0.2507 0.2900 0.3676 0.3830 0.2877 0.1962 0.2200 0.1642 0.3650 0.2703 0.1310 0.2727
0.3057 0.2590 0.2400 0.1219 0.1470 0.0810 0.0950 0.3252 0.3343 0.2050 0.2335 0.2794 0.4064
0.2113 0.4310 0.3270 0.1590 0.3053 0.2507 0.2847 0.2897 0.1892 0.2220 0.3696 0.1490 0.5350
0.1070 0.4064 0.1371 0.3140 0.2667 0.3610 0.1409 0.2320 0.3103 0.4104 0.1910 0.2863 0.2617
0.3486■
0.0711 0.0670 0.0410 0.0709 0.0600 0.2368 0.0871 0.0590 0.0240 0.0350 0.1241 0.0480 0.0300
0.0250 0.0240 0.1480 0.0320 0.0300 0.0210 0.0330 0.0610 0.1822 0.1780 0.0932 0.0788 0.1483
0.1529 0.1160 0.2800 0.1770 0.1131 0.2088 0.1778 0.1289 0.0792 0.0620 0.1528 0.1520 0.0950
0.1900 0.0921 0.1672 0.0690 0.1877 0.1770 0.1439 0.0600 0.1192 0.1862 0.2170 0.0871 0.1169
0.1437■
0.0140 0.0130 0.0120 0.0170 0.0080 0.0450 0.0440 0.0510 0.0040 0.0050 0.0110 0.0180 0.0090
0.0040 0.0060 0.0240 0.0160 0.0090 0.0070 0.0070 0.0233 0.0350 0.0530 0.0350 0.0340 0.0340
0.0453 0.0740 0.0940 0.0990 0.0961 0.0470 0.1148 0.0719 0.0340 0.0190 0.0360 0.0410 0.0710
0.0300 0.1512 0.0350 0.0570 0.0400 0.1110 0.0578 0.0650 0.0260 0.0651 0.0870 0.0831 0.0240
0.0571■
0.0030 0.0030 0.0020 0.0030 0.0010 0.0070 0.0050 0.0290 0.0020 0.0020 0.0000 0.0040 0.0040
0.0010 0.0000 0.0100 0.0030 0.0020 0.0000 0.0060 0.0078 0.0100 0.0090 0.0070 0.0160 0.0230
0.0201 0.0140 0.0520 0.0260 0.0370 0.0519 0.0320 0.0330 0.0130 0.0070 0.0110 0.0100 0.0160
0.0170 0.0230 0.0521 0.0140 0.0280 0.0270 0.0340 0.0260 0.0200 0.0180 0.0210 0.0260 0.0210
0.0183■
0.0010 0.0010 0.0000 0.0010 0.0000 0.0020 0.0010 0.0040 0.0000 0.0010 0.0000 0.0000 0.0010
0.0010 0.0010 0.0000 0.0010 0.0020 0.0000 0.0000 0.0011 0.0010 0.0050 0.0000 0.0050 0.0150
0.0100 0.0030 0.0210 0.0120 0.0060 0.0250 0.0310 0.0110 0.0060 0.0010 0.0040 0.0020 0.0030
0.0040 0.0140 0.0060 0.0150 0.0070 0.0110 0.0070 0.0150 0.0070 0.0070 0.0030 0.0060 0.0040
0.0102■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0020 0.0040
0.0040 0.0000 0.0060 0.0030 0.0030 0.0060 0.0130 0.0050 0.0010 0.0010 0.0010 0.0010 0.0000
0.0010 0.0020 0.0030 0.0010 0.0020 0.0040 0.0020 0.0010 0.0020 0.0010 0.0020 0.0010 0.0010
0.0031■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010
0.0020 0.0010 0.0040 0.0010 0.0000 0.0010 0.0030 0.0020 0.0000 0.0000 0.0010 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0010 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000■
0.1261 0.0200 0.1430 0.0270 0.1682 0.1000 0.0270 0.1289 0.0420 0.0891 0.4110 0.0470 0.0170
0.0250 0.0260 0.1360 0.1291 0.3392 0.2571 0.2192 0.1476 0.0320 0.0070 0.0802 0.0060 0.0020
0.0050 0.0070 0.0080 0.0289 0.0340 0.0320 0.0420 0.2170 0.2052 0.0380 0.1480 0.0260 0.0260
0.0050 0.0660 0.0160 0.0390 0.0300 0.0080 0.1420 0.0250 0.0230 0.0150 0.0621 0.0720 0.0700
0.0310■
0.3764 0.2917 0.5610 0.6326 0.5946 0.5810 0.7197 0.4865 0.4505 0.5475 0.3720 0.8172 0.4360
0.6020 0.3327 0.2680 0.6036 0.3772 0.4339 0.5135 0.4484 0.1852 0.3037 0.4309 0.5375 0.0890
0.1239 0.4016 0.1360 0.4381 0.3457 0.2400 0.2258 0.3720 0.5365 0.5040 0.1660 0.6100 0.1578
0.2723 0.2140 0.4790 0.2780 0.2230 0.1331 0.2120 0.6893 0.2178 0.2270 0.2332 0.4580 0.5330
0.3634■
0.4134 0.2498 0.2740 0.2763 0.1972 0.0950 0.2483 0.2707 0.2743 0.2332 0.1770 0.1028 0.4920
0.2580 0.4975 0.2610 0.2053 0.2169 0.2154 0.1662 0.3008 0.4815 0.2428 0.2395 0.1978 0.4690
0.3107 0.1788 0.5060 0.1497 0.2937 0.2780 0.2188 0.1360 0.1423 0.2970 0.3440 0.0770 0.6094

0.1241 0.2110 0.1052 0.4060 0.2380 0.2402 0.1300 0.0809 0.6024 0.2420 0.1972 0.2000 0.2300
0.3554■
0.0671 0.3705 0.0160 0.0551 0.0340 0.1900 0.0030 0.0629 0.1442 0.0882 0.0390 0.0250 0.0470
0.1040 0.1028 0.2320 0.0480 0.0524 0.0711 0.0761 0.0655 0.2463 0.3187 0.1363 0.1139 0.1980
0.3716 0.1678 0.1430 0.2196 0.1099 0.2610 0.2188 0.0920 0.0370 0.0830 0.2150 0.1470 0.0659
0.4735 0.1070 0.1343 0.0690 0.3050 0.2042 0.1880 0.0450 0.0648 0.3860 0.1772 0.0790 0.0760
0.1471■
0.0140 0.0500 0.0050 0.0070 0.0060 0.0260 0.0020 0.0290 0.0380 0.0280 0.0010 0.0080 0.0060
0.0080 0.0380 0.0910 0.0110 0.0082 0.0215 0.0170 0.0222 0.0350 0.1078 0.0891 0.0798 0.1300
0.1238 0.1848 0.1070 0.0729 0.1299 0.0540 0.1768 0.1000 0.0270 0.0310 0.0730 0.0990 0.0869
0.0450 0.3310 0.0601 0.0750 0.0810 0.2603 0.1310 0.0658 0.0290 0.0780 0.2733 0.0770 0.0290
0.0440■
0.0030 0.0150 0.0010 0.0010 0.0000 0.0050 0.0000 0.0170 0.0240 0.0090 0.0000 0.0000 0.0020
0.0030 0.0030 0.0120 0.0020 0.0030 0.0010 0.0060 0.0122 0.0110 0.0160 0.0220 0.0500 0.0810
0.0450 0.0440 0.0790 0.0609 0.0579 0.0920 0.0440 0.0590 0.0320 0.0220 0.0250 0.0280 0.0450
0.0591 0.0300 0.1704 0.0410 0.0510 0.0692 0.1420 0.0500 0.0310 0.0270 0.0370 0.0970 0.0320
0.0220■
0.0000 0.0030 0.0000 0.0010 0.0000 0.0020 0.0000 0.0040 0.0200 0.0030 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0010 0.0010 0.0000 0.0000 0.0033 0.0080 0.0030 0.0020 0.0130 0.0270
0.0170 0.0130 0.0150 0.0240 0.0240 0.0260 0.0538 0.0110 0.0170 0.0180 0.0140 0.0070 0.0070
0.0180 0.0340 0.0210 0.0770 0.0540 0.0460 0.0320 0.0340 0.0180 0.0140 0.0120 0.0130 0.0270
0.0220■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0010 0.0060 0.0010 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0021 0.0000 0.0010 0.0000 0.0010 0.0010 0.0000 0.0020 0.0040
0.0030 0.0020 0.0050 0.0050 0.0050 0.0140 0.0110 0.0110 0.0010 0.0060 0.0110 0.0040 0.0020
0.0020 0.0070 0.0120 0.0090 0.0160 0.0320 0.0140 0.0060 0.0110 0.0070 0.0060 0.0020 0.0030
0.0140■
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0010 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0010 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0010 0.0010 0.0010 0.0000 0.0030 0.0090 0.0020 0.0020 0.0010 0.0040 0.0020 0.0000
0.0010 0.0000 0.0020 0.0060 0.0020 0.0070 0.0090 0.0040 0.0030 0.0040 0.0020 0.0020 0.0000
0.0010■

' errorCheck_4■

"Single fish weight at age, WA row=year (stYr to endyr), col=age (recAge to maxAge), in gram from Schweigert (2002)■

58.0 67.3 84.9 98.6 114.0 125.7 141.9 141.9 141.9■
38.6 76.4 100.9 116.1 136.4 152.4 152.4 152.4 152.4■
38.6 76.4 100.9 116.1 136.4 152.4 152.4 152.4 152.4■
27.7 50.8 67.2 94.9 110.9 131.6 154.4 143.3 145■
39.9 57.8 85.7 114.5 135.2 161.2 174.3 215.0 200■
43.0 87.8 109.9 121.1 147.4 160.4 166.3 166.3 166.3■
41.3 86.3 119.1 134.7 143.3 164.9 166.1 185.0 185■
46.1 75.1 99.5 121.8 147.5 161.3 161.3 161.3 161.3■
62.0 88.0 98.4 117.1 147.5 161.3 161.3 161.3 161.3■
39.6 66.3 88.6 90.7 116.1 181.2 192.2 198.5 198.5■
41.3 76.0 101.8 124.2 140.5 201.0 201.0 201.0 201■
56.0 93.8 123.5 141.4 153.3 176.5 176.5 176.5 176.5■
58.0 87.9 118.5 143.6 165.9 161.9 161.9 173.0 184■
57.0 91.7 109.6 134.7 160.5 182.7 182.7 182.7 182.7■
56.5 96.9 112.8 147.5 182.2 183.0 256.5 256.5 256.5■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
58.4 101.5 130.2 161.8 201.3 208.9 240.4 246.0 246■
59.0 106.7 150.5 170.9 212.5 231.0 242.5 249.6 250■
73.3 99.0 145.0 179.5 212.8 235.7 239.5 239.5 239.5■
109.5 88.5 126.6 155.3 191.3 212.9 243.8 254.0 254■
58.9 86.9 119.7 155.8 188.5 206.2 208.6 229.5 229.5■
62.8 99.5 123.7 152.3 184.4 207.3 236.9 239.7 239.7■
54.0 105.5 133.5 150.3 177.0 202.3 217.6 242.8 242.8■
69.5 96.4 130.5 155.1 169.7 188.7 207.2 237.0 265.5■
59.3 104.4 130.0 160.4 173.0 189.1 210.5 210.5 210.5■
61.6 84.0 104.8 147.0 174.2 188.1 198.3 225.7 226.3■
63.6 97.6 113.5 132.1 160.4 177.3 183.8 195.2 195.3■

```
63.9    102.5   119.8   128.3   141.6   165.5   174.3   192.7   203■
68.8    98.1    124.9   140.9   154.6   166.6   178.8   200.3   202■
64.2    93.6    115.5   135.5   141.1   151.9   172.0   184.2   195.3■
62.2    101.2   127.6   146.8   161.1   165.7   185.8   205.7   193■
77.3    116.8   140.9   158.9   171.2   180.4   188.2   202.3   225.8■
66.7    106.6   131.8   151.1   167.6   174.2   179.8   188.2   199.1■
61.0    89.0    124.9   150.0   165.8   181.7   191.6   203.2   193.7■
62.0    92.7    119.0   145.1   158.9   178.1   192.3   193.2   203.3■
66.1    97.7    115.9   139.0   153.7   166.8   183.8   192.6   180.4■
60.4    84.9    113.1   127.3   141.8   156.4   163.3   176.5   180.9■
58.6    94.7    120.0   143.1   147.4   174.5   178.9   174.2   191■
77.1    100.9   115.5   128.1   147.6   153.4   161.0   182.8   181■
69.2    94.3    119.1   125.0   138.0   148.2   146.9   155.0   184.6■
62.6    97.2    134.9   139.8   151.9   159.5   182.3   175.8   186■
55.2    89.6    110.3   130.8   139.0   151.2   153.0   160.3   132.5■
59.1    87.7    105.3   121.7   151.0   152.0   160.5   163.2   171■
62.1    80.3    84.1    109.1   120.4   136.0   139.7   147.8   150.4■
57.3    88.8    103.2   110.6   127.5   137.0   148.3   141.3   170.1■
58.9    81.8    96.9    114.5   128.8   136.6   144.3   142.8   157.7■
57.5    80.4    99.9    114.9   131.1   142.2   160.5   167.0   211■
55.7    69.9    101.3   102.7   144.5   127.3   130.0   130.0   130■
55.7    69.9    101.3   102.7   144.5   127.3   130.0   130.0   130■
55.7    69.9    101.3   102.7   144.5   127.3   130.0   130.0   130■
' errorCheck_5■
'Tag release data from herring database, row=year (stYr to endYr),  col=stk (1 to Nstocks) in million fish■
0       0.005091 0.015626 0.016317 0.032072■
0.004114 0.008089 0.008837 0.011516 0.054193■
0.004111 0.006244 0.015610 0.027660 0.053041■
0.007066 0.008089 0.006081 0.011088 0.006141■
0       0.001500 0       0.032105 0■
0.004185 0       0       0.039498 0■
0       0.002443 0.002530 0.000239 0■
0       0       0       0.010412 0■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0■
0.017568 0.002000 0.014000 0       0■
0       0       0       0       0.011928■
0       0       0       0       0.000482■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0■
0       0       0       0       0
```

```
        0          0          0          0          0■
        0          0          0          0          0■
        0          0          0          0          0■
        0          0          0          0          0■
        0          0          0          0          0■
        0          0          0          0          0■
        0          0          0          0          0■
        0.006175   0          0          0.047712   0■
        0          0          0          0.248391   0■
        0          0.088196   0          0.060558   0■
        0          0.085742   0.058658   0.083528   0■
        0          0.111500   0.119342   0.095890   0 ■
' errorCheck_6■
'SearchR_stk_gr_yr: ratio of fish search for tag. Row=year(stYr to endYr); col=stk(1 to Nstocks), Gear=(1 to Ngears) ■
 1 1 1
```

313.46 463.54 517.23 163.75 501.04 195.22 226.80 420.11 314.51 865.99 484.94
371.66 729.43 209.77 176.63 115.77 75.03 77.00 126.35 126.51 74.46 158.42
187.85 123.13 93.69 137.04 63.03 38.45 264.48 127.75 126.24 137.33 396.61
153.61 114.67 273.66 236.68 151.75 97.71 261.14 279.38 132.96 67.65 140.73
272.03 157.15 293.32 85.92 161.89 171.23 146.41 427.63 152.68 ■

"CC■

128.44 244.23 955.59 235.89 301.13 276.43 284.03 452.48 124.25 319.64 641.29
233.32 360.33 162.31 144.16 162.54 56.94 58.80 122.39 165.40 168.22 163.54
170.02 239.14 159.91 84.91 77.79 63.44 347.78 137.14 144.76 67.01 64.50
125.44 74.33 115.00 479.42 97.41 58.65 170.91 527.69 139.73 144.10 57.06
142.93 351.33 346.23 118.23 169.73 85.45 174.47 332.05 177.96 ■

"GS■

963.98 1580.01 1607.83 1179.74 697.56 655.64 514.96 1084.89 1073.86 879.37 1258.43
1222.17 1109.16 615.42 338.86 376.58 235.78 276.35 439.46 543.21 532.18 410.46
460.98 587.19 555.38 945.82 798.26 529.10 713.05 658.41 685.73 572.51 511.13
473.10 560.41 350.61 652.65 359.84 597.64 432.72 784.71 745.25 760.74 483.90
648.55 878.11 885.17 671.73 750.49 898.91 1123.09 1766.45 660.11 ■

"WCVI■

149.55 598.58 436.73 425.16 915.21 1426.58 469.68 415.04 517.15 349.25 621.69
331.27 404.60 172.70 128.33 224.58 80.44 144.69 283.13 485.02 462.75 435.82
513.36 683.46 468.48 286.87 608.09 248.11 506.14 487.68 238.02 160.30 215.12
325.60 397.26 202.62 490.61 238.61 247.25 192.27 360.93 273.15 210.83 137.77
205.40 627.72 354.13 236.23 186.74 169.91 261.94 392.40 446.54 ■

' errorCheck_9■

'Stray_stkS_stkD. Row=Source Stock(1 to Nstocks), col=Destination Stock(1 to Nstocks) ■

0.8431 0.0072 0.1061 0.0060 0.0375■
0.0627 0.9262 0.0062 0.0002 0.0046■
0.0265 0.1318 0.7909 0.0015 0.0494■
0.0040 0.0048 0.0051 0.9617 0.0243■
0.0023 0.0007 0.0165 0.1866 0.7939■

' errorCheck_10■

"Sel_stk_gr_age. Row=stk(1 to Nstocks){gear=(1 to Ngears)}; col=age(recAge to maxAge) ■

1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00■
0.01 0.04 0.26 0.61 0.84 1.00 1.00 1.00 1.00■
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00■
0.00 0.01 0.16 0.44 0.71 1.00 1.00 1.00 1.00■
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00■
0.00 0.03 0.19 0.50 0.76 1.00 1.00 1.00 1.00■
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00■
0.00 0.02 0.19 0.50 0.79 1.00 1.00 1.00 1.00■
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00■
0.00 0.03 0.30 0.67 0.89 1.00 1.00 1.00 1.00 ■

' errorCheck_11■

Appendix III. Partial format of the input file "ObsRec.txt" showing tag recoveries for the six years following a release event.

*2002,3,

Year	0	1	2	3	4	5	6
2002	0	0	0	510	0	0	0
2003	0	0	0	245	0	4	0
2004	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0

'*2002,5,

Year	0	1	2	3	4	5	6
2002	2	0	0	0	0	1011	0
2003	0	0	0	0	0	108	2
2004	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0

'*2003,3,

Year	0	1	2	3	4	5	6
2003	0	0	0	294	0	0	0
2004	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0

'*2003,5,

Year	0	1	2	3	4	5	6
2003	0	0	0	0	0	39	0
2004	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0

Appendix IV. Simulated tag recovery output and the observed tag recoveries from the 5 regions (Stocks), from release year through the subsequent 8 years at large. The predicted tag recoveries are shown beginning in 1951. Tag release year, region (Stock), and number of tags released are shown in the table headings. The result presented here is the 159th of 500 replicates. Start time and end time indicate the total elapsed time for all 500 replicate simulations.

'This is looper: 159 / 500

'Start time = 27/02/2004 10:39:08 AM

'End time = 27/02/2004 10:39:38 AM

'Release Year: 1951;Region:2;Number:5091 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1951	0/0	0/0	0/0	0/0	0/0
1952	1/0	176/392	0/20	0/2	0/2
1953	0/0	1/0	0/0	0/0	0/0
1954	0/0	5/94	0/4	0/0	0/0
1955	0/1	0/6	0/0	0/0	0/0
1956	0/1	0/0	0/0	0/0	0/0
1957	0/0	0/0	0/0	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1951;Region:3;Number:15626 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1951	0/0	0/0	0/0	0/0	7/0
1952	0/0	11/250	464/1525	0/0	2/7
1953	0/0	0/0	3/0	0/0	0/0
1954	0/0	0/23	5/180	0/0	0/0
1955	0/0	0/6	0/5	0/0	0/0
1956	0/1	0/0	0/8	0/0	0/0
1957	0/0	0/1	0/7	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1951;Region:4;Number:16317 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1951	0/0	0/0	0/0	62/0	3/0
1952	0/0	0/0	0/1	397/224	0/6
1953	0/0	0/0	0/0	11/0	0/0
1954	0/0	0/0	0/0	46/14	0/2
1955	0/0	0/0	0/0	2/7	0/0
1956	0/0	0/0	0/0	1/6	0/0
1957	0/0	0/0	0/0	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1951;Region:5;Number:32072 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1951	0/0	0/0	0/0	24/0	216/0
1952	0/0	0/0	0/0	28/3	873/386
1953	0/0	0/0	0/0	0/0	0/1
1954	0/0	0/0	0/1	0/0	6/77
1955	0/0	0/0	0/0	0/0	0/0
1956	0/0	0/0	0/0	0/0	0/1
1957	0/0	0/0	0/0	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/1

'ReleaseYear:1952;Region:1;Number:4114 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1952	0/0	0/0	0/0	0/0	0/0
1953	0/0	0/0	0/0	0/0	0/0
1954	6/4	0/2	0/1	0/0	0/0
1955	1/2	0/2	0/0	0/0	0/0
1956	9/64	0/0	0/2	0/0	0/0
1957	1/10	0/2	0/0	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1952;Region:2;Number:8089 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1952	0/0	0/0	0/0	0/0	0/0
1953	0/0	23/0	0/0	0/0	0/0
1954	0/0	111/221	0/8	0/0	0/0
1955	0/2	10/15	0/0	0/0	0/0
1956	0/4	1/1	0/0	0/0	0/0
1957	0/0	1/2	0/0	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1952;Region:3;Number:8837 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1952	0/0	0/0	0/0	0/0	0/0
1953	0/0	1/0	29/0	0/0	0/0
1954	0/0	0/4	50/256	0/0	0/0
1955	0/0	0/1	6/13	0/0	0/0
1956	0/3	0/0	5/31	0/0	0/0
1957	0/1	0/0	0/29	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1952;Region:4;Number:11516 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1952	0/0	0/0	0/0	19/0	0/0
1953	0/0	0/0	0/0	42/0	0/0
1954	0/0	0/0	0/0	180/30	0/8
1955	0/0	0/0	0/0	11/5	0/0
1956	0/0	0/0	0/0	4/1	0/0
1957	0/0	0/0	0/0	1/1	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1952;Region:5;Number:54193 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1952	0/0	0/0	0/0	17/0	0/1
1953	0/0	0/0	0/0	7/0	1/3
1954	0/0	0/0	0/0	6/12	462/516
1955	0/0	0/0	0/1	0/3	7/10
1956	0/0	0/0	0/0	0/1	6/7
1957	0/1	0/0	0/0	0/0	0/1
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/1	0/0	0/3
1960	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1953;Region:1;Number:4111 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1953	0/0	0/0	0/0	0/0	0/0
1954	8/7	0/0	1/2	0/0	0/1
1955	2/3	0/3	0/0	0/0	0/0
1956	12/156	0/0	0/0	0/0	0/0
1957	1/23	0/4	0/2	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1953;Region:2;Number:6244 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1953	0/0	0/0	0/0	0/0	0/0
1954	0/1	133/352	0/5	0/0	0/0
1955	0/7	12/100	0/1	0/0	0/0
1956	0/21	1/2	0/4	0/0	0/0
1957	0/2	1/10	0/2	0/0	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1953;Region:3;Number:15610 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1953	0/0	0/0	0/0	0/0	0/0
1954	0/0	7/32	142/797	0/0	1/1
1955	0/2	0/3	18/32	0/0	0/5
1956	0/15	0/2	18/125	0/3	0/0
1957	0/2	0/4	2/66	0/0	0/0
1958	0/0	0/0	0/2	0/0	0/0

1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1953;Region:4;Number:27660 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1953	0/0	0/0	0/0	115/1	0/0
1954	0/0	0/0	0/0	498/71	0/25
1955	0/0	0/1	0/2	33/7	0/0
1956	0/0	0/0	0/0	12/4	0/0
1957	0/0	0/0	0/0	3/1	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1953;Region:5;Number:53041 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1953	0/0	0/0	0/0	43/0	0/0
1954	0/0	0/0	0/1	36/25	761/969
1955	0/0	0/0	0/0	0/10	14/32
1956	0/1	0/0	0/1	0/1	15/11
1957	0/0	0/0	0/0	0/1	0/3
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	1/10
1960	0/0	0/0	0/0	0/1	0/1
1961	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1954;Region:1;Number:7066 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1954	0/0	0/0	0/0	0/0	0/0
1955	15/597	0/33	1/0	0/0	0/0
1956	136/304	0/1	0/7	0/1	0/0
1957	10/48	0/18	0/2	0/0	0/0
1958	0/0	0/0	0/1	0/0	0/0
1959	0/11	0/0	0/0	0/0	0/1
1960	0/0	0/1	0/0	0/0	0/0
1961	0/2	0/1	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1954;Region:2;Number:8089 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1954	0/0	0/0	0/0	0/0	0/0
1955	0/6	277/394	0/7	0/0	0/0
1956	0/63	24/5	0/14	0/1	0/0
1957	0/3	27/50	0/8	0/0	0/0
1958	0/0	1/0	0/0	0/0	0/0
1959	0/0	1/0	0/0	0/0	0/0
1960	0/0	0/1	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1954;Region:3;Number:6081 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1954	0/0	0/0	0/0	0/0	0/0
1955	0/0	5/7	66/56	0/0	0/0
1956	0/13	0/2	75/236	0/1	0/0
1957	0/5	0/0	9/29	0/2	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/3	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1954;Region:4;Number:11088 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1954	0/0	0/0	0/0	57/0	0/0
1955	0/0	0/1	0/0	292/125	0/2
1956	0/0	0/0	0/2	108/27	0/0
1957	0/0	0/0	0/0	27/6	0/0
1958	0/0	0/0	0/0	2/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1954;Region:5;Number:6141 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1954	0/0	0/0	0/0	6/0	4/0

1955	0/0	0/0	0/0	6/3	37/6
1956	0/0	0/0	0/1	0/2	36/7
1957	0/1	0/0	0/0	0/0	1/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	3/9
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1955;Region:2;Number:1500 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1955	0/0	2/0	0/0	0/0	0/0
1956	0/0	3/0	0/0	0/5	0/0
1957	0/0	4/0	0/0	0/4	0/0
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1955;Region:4;Number:32105 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1955	0/0	0/0	0/0	0/0	1/0
1956	0/0	0/0	0/3	212/213	0/6
1957	0/0	0/0	0/2	49/36	0/0
1958	0/0	0/0	0/2	4/0	0/0
1959	0/0	0/0	0/0	1/1	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1956;Region:1;Number:4185 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1956	6/0	0/0	1/0	0/0	1/0
1957	15/0	0/0	0/0	0/0	0/0
1958	1/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1956;Region:4;Number:39498 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1956	0/0	0/0	0/0	140/141	4/8
1957	0/0	0/0	0/3	132/138	0/3
1958	0/0	0/0	0/3	11/0	0/0
1959	0/0	0/0	0/0	2/9	0/5
1960	0/0	0/0	0/0	0/3	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1957;Region:2;Number:2443 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1957	1/0	3/0	0/0	0/0	0/0
1958	0/0	21/1	0/2	0/0	0/0
1959	0/26	22/0	0/3	0/0	0/0
1960	0/0	8/10	0/0	0/0	0/0
1961	0/0	5/3	0/1	0/0	0/0
1962	0/0	1/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0
1965	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1957;Region:3;Number:2530 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1957	0/0	0/0	0/0	0/0	0/0
1958	0/0	0/0	42/54	0/0	0/0
1959	0/6	0/0	25/42	0/1	0/0
1960	0/0	0/5	1/0	0/0	0/0
1961	0/0	0/5	2/4	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0
1965	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1957;Region:4;Number:239 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1957	0/0	0/0	0/0	22/23	0/0
1958	0/0	0/0	0/0	2/0	0/0
1959	0/0	0/0	0/0	0/0	0/0
1960	0/0	0/0	0/0	0/0	0/0
1961	0/0	0/0	0/0	0/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0
1965	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1958;Region:4;Number:10412 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1958	0/0	0/0	0/0	0/0	0/0
1959	0/0	0/0	0/0	14/14	0/5
1960	0/0	0/0	0/0	5/4	0/0
1961	0/0	0/0	0/0	1/0	0/0
1962	0/0	0/0	0/0	0/0	0/0
1963	0/0	0/0	0/0	0/0	0/0
1964	0/0	0/0	0/0	0/0	0/0
1965	0/0	0/0	0/0	0/0	0/0
1966	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1964;Region:1;Number:17568 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1964	23/0	6/1	0/1	1/0	0/0
1965	1,056/1052 1/0		0/52	14/20	0/0
1966	45/50	0/3	0/3	0/0	0/0
1967	2/0	0/0	0/26	0/0	0/0
1968	0/0	0/0	0/0	0/0	0/0
1969	0/0	0/0	0/0	0/0	0/0
1970	0/0	0/0	0/0	0/0	0/0
1971	0/0	0/0	0/0	0/0	0/0
1972	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1964;Region:2;Number:2000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1964	0/0	83/36	0/0	0/0	0/0
1965	1/6	121/29	0/3	0/0	0/0
1966	0/0	9/0	0/1	0/0	0/0
1967	0/0	1/0	0/0	0/0	0/0
1968	0/0	0/0	0/0	0/0	0/0
1969	0/0	0/0	0/0	0/0	0/0
1970	0/0	0/0	0/0	0/0	0/0
1971	0/0	0/0	0/0	0/0	0/0
1972	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1964;Region:3;Number:14000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1964	1/0	82/86	0/31	0/0	0/0
1965	1/31	17/4	689/621	0/0	2/0
1966	0/1	0/0	135/775	0/0	0/0
1967	0/0	0/0	15/236	0/0	0/0
1968	0/0	0/0	0/0	0/0	0/0
1969	0/0	0/0	0/0	0/0	0/0
1970	0/0	0/0	0/0	0/0	0/0
1971	0/0	0/0	0/0	0/0	0/0
1972	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1965;Region:5;Number:11928 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1965	1/0	1/0	0/0	0/0	1/0
1966	0/0	0/0	0/0	44/120	801/816
1967	0/0	0/0	0/0	1/14	107/45
1968	0/0	0/0	0/0	0/0	0/0
1969	0/0	0/0	0/0	0/0	0/0
1970	0/0	0/0	0/0	0/0	0/0
1971	0/0	0/0	0/0	0/0	0/0
1972	0/0	0/0	0/0	0/0	0/0
1973	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1966;Region:5;Number:482 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1966	0/0	0/0	0/0	1/0	21/21
1967	0/0	0/0	0/0	1/0	7/7
1968	0/0	0/0	0/0	0/0	0/0

1969	0/0	0/0	0/0	0/0	0/0
1970	0/0	0/0	0/0	0/0	0/0
1971	0/0	0/0	0/0	0/0	0/0
1972	0/0	0/0	0/0	0/0	0/0
1973	0/0	0/0	0/0	0/0	0/0
1974	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1979;Region:4;Number:3554 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1979	0/0	1/0	0/0	26/26	1/0
1980	0/0	0/0	0/0	3/3	0/0
1981	0/0	0/0	0/0	0/3	0/0
1982	0/0	0/0	0/0	0/0	0/0
1983	0/0	0/0	0/0	0/0	0/0
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1980;Region:1;Number:7719 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1980	2/2	0/1	0/0	0/0	0/0
1981	5/5	0/1	0/0	0/0	0/0
1982	0/2	0/0	0/0	0/0	0/0
1983	0/0	0/0	0/0	0/0	0/0
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1980;Region:2;Number:10260 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1980	0/0	6/6	0/0	0/0	0/0
1981	0/2	7/3	0/0	0/0	0/0
1982	0/0	0/0	0/0	0/0	0/0
1983	0/2	0/0	0/0	0/0	0/0
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1980;Region:3;Number:10485 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1980	0/0	1/0	2/2	0/0	0/0
1981	0/0	0/0	1/1	0/0	0/0
1982	0/0	0/0	0/1	0/0	0/0
1983	0/0	0/0	0/0	0/0	0/0
1984	0/0	0/0	0/2	0/0	0/0
1985	0/0	0/0	0/1	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1980;Region:4;Number:14868 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1980	0/0	0/0	0/0	23/24	0/0
1981	0/0	0/0	0/0	6/13	0/0
1982	0/0	0/0	0/1	0/9	0/0
1983	0/0	0/0	0/0	0/1	0/0
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1980;Region:5;Number:25036 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1980	0/0	0/0	0/0	8/5	2/2
1981	0/0	0/0	0/0	0/4	9/9
1982	0/1	0/0	0/0	0/1	0/6
1983	0/0	0/0	0/0	0/1	0/1
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1981;Region:1;Number:14344 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1981	8/8	0/1	0/0	1/0	1/0
1982	52/11	0/0	0/0	0/0	0/0
1983	3/2	0/0	0/0	0/0	0/0
1984	0/3	0/0	0/0	0/0	0/0
1985	0/1	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1981;Region:2;Number:12904 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1981	1/0	21/22	0/0	0/0	0/0
1982	0/0	46/2	0/0	0/0	0/0
1983	0/0	1/1	0/0	0/0	0/0
1984	0/0	0/0	0/0	0/0	0/0
1985	0/0	0/1	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1981;Region:3;Number:18298 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1981	0/0	4/0	4/4	0/0	1/0
1982	0/0	1/0	27/6	0/0	0/1
1983	0/0	0/0	2/0	0/1	0/0
1984	0/0	0/0	0/1	0/0	0/0
1985	0/0	0/0	0/1	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1981;Region:4;Number:42373 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1981	0/0	0/0	0/0	314/319	1/1
1982	0/0	0/0	0/1	126/191	0/3
1983	0/0	0/0	0/0	17/18	0/4
1984	0/0	0/0	0/0	1/6	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1981;Region:5;Number:19784 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1981	0/0	0/0	0/0	30/3	18/18
1982	0/0	0/0	0/0	2/13	33/18
1983	0/0	0/0	0/0	0/7	3/4
1984	0/0	0/0	0/0	0/0	0/1
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1982;Region:2;Number:17443 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1982	0/0	66/66	0/0	0/0	1/0
1983	0/2	9/1	0/0	0/0	0/0
1984	0/0	3/1	0/0	0/0	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1982;Region:4;Number:24416 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1982	0/0	0/0	0/0	81/84	9/0
1983	0/0	0/0	0/0	113/128	0/15
1984	0/0	0/0	0/0	8/2	0/0
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0

1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1982;Region:5;Number:17860 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1982	0/0	0/0	1/0	12/0	230/231
1983	0/1	0/0	0/0	3/2	38/17
1984	0/1	0/0	0/0	0/0	1/4
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1983;Region:3;Number:2464 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1983	1/0	1/0	0/0	0/0	1/0
1984	0/0	0/0	5/0	0/0	0/1
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1983;Region:4;Number:20937 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1983	1/0	0/0	0/0	11/12	3/0
1984	0/0	0/0	0/0	51/63	0/0
1985	0/0	0/0	0/0	3/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1983;Region:5;Number:15736 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1983	0/0	0/0	0/0	2/0	89/89
1984	0/0	0/0	0/0	1/1	28/5
1985	0/0	0/0	0/0	0/0	0/0
1986	0/0	0/0	0/0	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1985;Region:3;Number:8900 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1985	1/0	3/2	69/69	0/2	0/0
1986	0/0	0/0	4/3	0/0	0/0
1987	0/0	0/0	0/0	0/0	0/0
1988	0/0	0/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1986;Region:2;Number:8969 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1986	14/14	283/285	1/1	0/0	0/0
1987	0/0	24/0	0/0	0/0	0/0
1988	0/0	3/0	0/0	0/0	0/0
1989	0/0	0/0	0/0	0/0	0/0
1990	0/0	0/0	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1988;Region:2;Number:9991 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1988	1/0	256/258	1/2	0/0	1/0

1989	0/0	30/12	0/0	0/0	0/1
1990	0/0	2/4	0/0	0/0	0/0
1991	0/0	0/0	0/0	0/0	0/0
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1989;Region:3;Number:19957 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1989	7/7	12/12	254/255	0/3	6/10
1990	0/4	1/0	23/29	0/1	0/2
1991	0/2	0/1	2/13	0/1	0/0
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1989;Region:4;Number:28962 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1989	1/0	1/3	2/4	92/93	4/8
1990	0/0	0/1	0/1	17/10	0/3
1991	0/0	0/0	0/0	3/0	0/0
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1989;Region:5;Number:17924 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1989	1/0	0/1	5/1	12/10	93/93
1990	0/0	0/1	0/2	0/2	16/12
1991	0/0	0/0	0/0	0/0	1/8
1992	0/0	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1990;Region:1;Number:12370 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1990	358/360	2/11	25/20	1/1	3/7
1991	3/29	0/6	0/5	0/3	0/2
1992	0/3	0/0	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1990;Region:2;Number:9982 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1990	21/18	208/223	1/18	0/3	0/2
1991	0/0	11/6	0/2	0/0	0/1
1992	0/0	1/1	0/0	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1990;Region:3;Number:19957 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1990	20/19	62/14	309/311	0/6	7/15
1991	0/6	0/0	40/40	0/0	0/3
1992	0/0	0/0	2/2	0/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1990;Region:4;Number:18957 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1990	1/2	2/2	2/9	89/141	3/15
1991	0/0	0/0	0/1	29/8	0/3
1992	0/0	0/0	0/0	2/0	0/0
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1990;Region:5;Number:34408 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1990	2/3	1/1	10/12	66/13	174/174
1991	0/2	0/0	0/3	3/2	55/19
1992	0/0	0/0	0/0	0/0	1/1
1993	0/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1991;Region:1;Number:8495 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1991	76/108	1/2	13/11	0/4	3/1
1992	15/12	0/1	0/1	0/0	0/0
1993	1/0	0/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0
1999	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1991;Region:2;Number:14972 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1991	10/19	150/150	1/16	0/0	1/3
1992	0/0	45/4	0/0	0/0	0/0
1993	0/0	6/0	0/0	0/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0
1999	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1991;Region:4;Number:12624 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1991	1/5	1/2	1/4	37/37	3/4
1992	0/0	0/0	0/0	26/1	0/0
1993	0/0	0/0	0/0	1/0	0/0
1994	0/0	0/0	0/0	0/0	0/0
1995	0/0	0/0	0/0	0/0	0/0
1996	0/0	0/0	0/0	0/0	0/0
1997	0/0	0/0	0/0	0/0	0/0
1998	0/0	0/0	0/0	0/0	0/0
1999	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1999;Region:1;Number:6175 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1999	0/0	0/0	0/0	0/0	0/0
2000	7/4	0/0	0/1	0/0	0/0
2001	0/0	0/0	0/0	0/0	0/0
2002	1/1	0/0	0/0	0/0	0/0
2003	0/0	0/0	0/0	0/0	0/0
2004	0/0	0/0	0/0	0/0	0/0
2005	0/0	0/0	0/0	0/0	0/0
2006	0/0	0/0	0/0	0/0	0/0
2007	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:1999;Region:4;Number:47712 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
1999	0/0	0/0	0/0	0/0	0/0
2000	0/0	0/0	0/0	150/120	0/2
2001	0/0	0/0	0/0	61/113	0/0
2002	0/0	0/0	0/0	21/80	0/1

2003	0/0	0/0	0/0	1/17	0/1
2004	0/0	0/0	0/0	0/0	0/0
2005	0/0	0/0	0/0	0/0	0/0
2006	0/0	0/0	0/0	0/0	0/0
2007	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2000;Region:4;Number:248391 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2000	1/0	1/0	1/0	402/403	0/0
2001	0/0	0/0	0/1	388/335	0/0
2002	0/0	0/0	0/0	158/298	0/0
2003	0/0	0/0	0/0	13/89	0/5
2004	0/0	0/0	0/0	7/0	0/0
2005	0/0	0/0	0/0	1/0	0/0
2006	0/0	0/0	0/0	0/0	0/0
2007	0/0	0/0	0/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2001;Region:2;Number:88196 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2001	0/0	49/47	1/0	0/0	0/0
2002	1/0	200/157	0/1	0/0	0/0
2003	0/0	40/104	0/10	0/0	0/0
2004	0/0	17/0	0/0	0/0	0/0
2005	0/0	4/0	0/0	0/0	0/0
2006	0/0	1/0	0/0	0/0	0/0
2007	0/0	0/0	0/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2001;Region:4;Number:60558 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2001	0/0	0/0	0/0	83/84	0/0
2002	0/0	0/0	0/2	182/197	0/0
2003	0/0	0/0	0/0	22/64	0/1
2004	0/0	0/0	0/0	13/0	0/0
2005	0/0	0/0	0/0	3/0	0/0
2006	0/0	0/0	0/0	1/0	0/0
2007	0/0	0/0	0/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2002;Region:2;Number:85742 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2002	0/0	333/337	6/0	0/0	0/0
2003	0/0	200/147	0/18	0/0	0/0
2004	0/0	93/0	0/0	0/0	0/0
2005	0/0	25/0	0/0	0/0	0/0
2006	0/0	6/0	0/0	0/0	0/0
2007	0/0	1/0	0/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2002;Region:3;Number:58658 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2002	0/0	41/0	510/510	2/0	0/0
2003	0/0	3/0	279/245	0/4	0/0
2004	0/0	0/0	40/0	0/0	0/0
2005	0/0	0/0	9/0	0/0	0/0
2006	0/0	0/0	2/0	0/0	0/0
2007	0/0	0/0	0/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2002;Region:4;Number:83528 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2002	0/0	1/0	5/0	970/1011	0/0
2003	0/0	0/0	0/0	183/108	0/2
2004	0/0	0/0	0/0	99/0	0/0
2005	0/0	0/0	0/0	30/0	0/0
2006	0/0	0/0	0/0	7/0	0/0
2007	0/0	0/0	0/0	1/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2003;Region:2;Number:111500 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2003	0/0	0/0	2/0	0/0	0/0
2004	0/0	123/0	0/0	0/0	0/0
2005	0/0	37/0	0/0	0/0	0/0
2006	0/0	11/0	0/0	0/0	0/0
2007	0/0	3/0	0/0	0/0	0/0
2008	0/0	1/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2003;Region:3;Number:119342 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2003	0/0	0/0	293/294	0/0	1/0
2004	0/0	3/0	87/0	0/0	0/0
2005	0/0	0/0	24/0	0/0	0/0
2006	0/0	0/0	6/0	0/0	0/0
2007	0/0	0/0	1/0	0/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2003;Region:4;Number:95890 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2003	0/0	0/0	1/0	39/39	0/0
2004	0/0	0/0	0/0	99/0	0/0
2005	0/0	0/0	0/0	31/0	0/0
2006	0/0	0/0	0/0	9/0	0/0
2007	0/0	0/0	0/0	2/0	0/0
2008	0/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2004;Region:1;Number:50000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2004	147/0	1/0	15/0	1/0	3/0
2005	96/0	0/0	2/0	0/0	0/0
2006	25/0	0/0	0/0	0/0	0/0
2007	6/0	0/0	0/0	0/0	0/0
2008	1/0	0/0	0/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0
2012	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2004;Region:2;Number:50000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2004	11/0	111/0	1/0	0/0	0/0
2005	1/0	128/0	0/0	0/0	0/0
2006	0/0	39/0	0/0	0/0	0/0
2007	0/0	11/0	0/0	0/0	0/0
2008	0/0	3/0	0/0	0/0	0/0
2009	0/0	1/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0
2012	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2004;Region:3;Number:50000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2004	5/0	17/0	117/0	0/0	4/0
2005	0/0	3/0	93/0	0/0	0/0
2006	0/0	0/0	26/0	0/0	0/0
2007	0/0	0/0	6/0	0/0	0/0
2008	0/0	0/0	1/0	0/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0
2011	0/0	0/0	0/0	0/0	0/0
2012	0/0	0/0	0/0	0/0	0/0

'ReleaseYear:2004;Region:4;Number:50000 (Simulated/Observed).

'Recovery----------Regions----------

Year	1	2	3	4	5
2004	1/0	1/0	1/0	196/0	2/0
2005	0/0	0/0	0/0	119/0	0/0
2006	0/0	0/0	0/0	38/0	0/0
2007	0/0	0/0	0/0	11/0	0/0
2008	0/0	0/0	0/0	2/0	0/0
2009	0/0	0/0	0/0	0/0	0/0
2010	0/0	0/0	0/0	0/0	0/0

2011	0/0	0/0	0/0	0/0	0/0	2006	0/0	0/0	0/0	0/0	28/0
2012	0/0	0/0	0/0	0/0	0/0	2007	0/0	0/0	0/0	0/0	7/0
						2008	0/0	0/0	0/0	0/0	1/0
'ReleaseYear:2004;Region:5;Number:50000 (Simulated/Observed).						2009	0/0	0/0	0/0	0/0	0/0
'Recovery----------Regions----------						2010	0/0	0/0	0/0	0/0	0/0
Year	1	2	3	4	5	2011	0/0	0/0	0/0	0/0	0/0
2004	0/0	0/0	2/0	39/0	65/0	2012	0/0	0/0	0/0	0/0	0/0
2005	0/0	0/0	0/0	4/0	101/0						